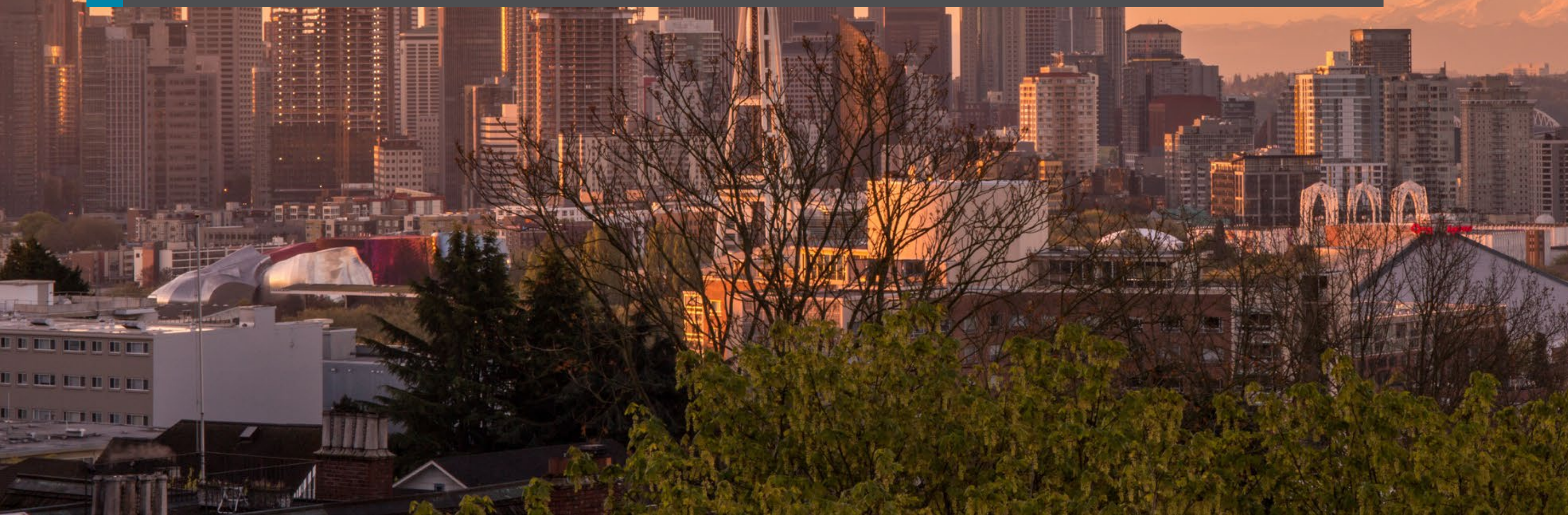
Kitsap County Communitywide Geographic Greenhouse Gas Emissions

Puget Sound Regional Emissions Analysis

Cascadia Consulting Group

FINAL REPORT

August 2022



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Executive Summary

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

This report provides a comprehensive **update of Kitsap County's communitywide geographic GHG emissions through 2019**. This update includes the following additional analyses:

- A **progress update** of historical trends and progress toward the County's GHG emission reduction goals.
- A **contribution analysis** update to explore 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 countywide climate goals.

What is a communitywide geographic GHG emissions inventory?

A communitywide geographic GHG emissions inventory quantifies the annual emissions produced within community boundaries due to community activities, such as on-road transportation and energy consumption. A geographic emissions inventory does not account for upstream emissions from goods and services consumed within the community, such as food or furniture.

Geographic Inventory Findings

- In 2019, Kitsap County's residents, businesses, employees, and visitors produced 3.2 million metric tons of CO_2 equivalent ($MTCO_2e$) (Figure 11).
- This equates to roughly 12.0 $MTCO_2e$ per capita in 2019.
- Total GHG emissions in 2019 increased 16% compared to the last inventory year (2015; Figure 22).
- Per-capita GHG emissions have increased 11% compared to the last inventory year (2015; Figure 22).
- The largest GHG emissions sources are building electricity (~36%), onroad transportation (~19%), and tree loss (~17%) (Figure 11, Figure 33).

Figure 1. Sources of greenhouse gas emissions in 2019.

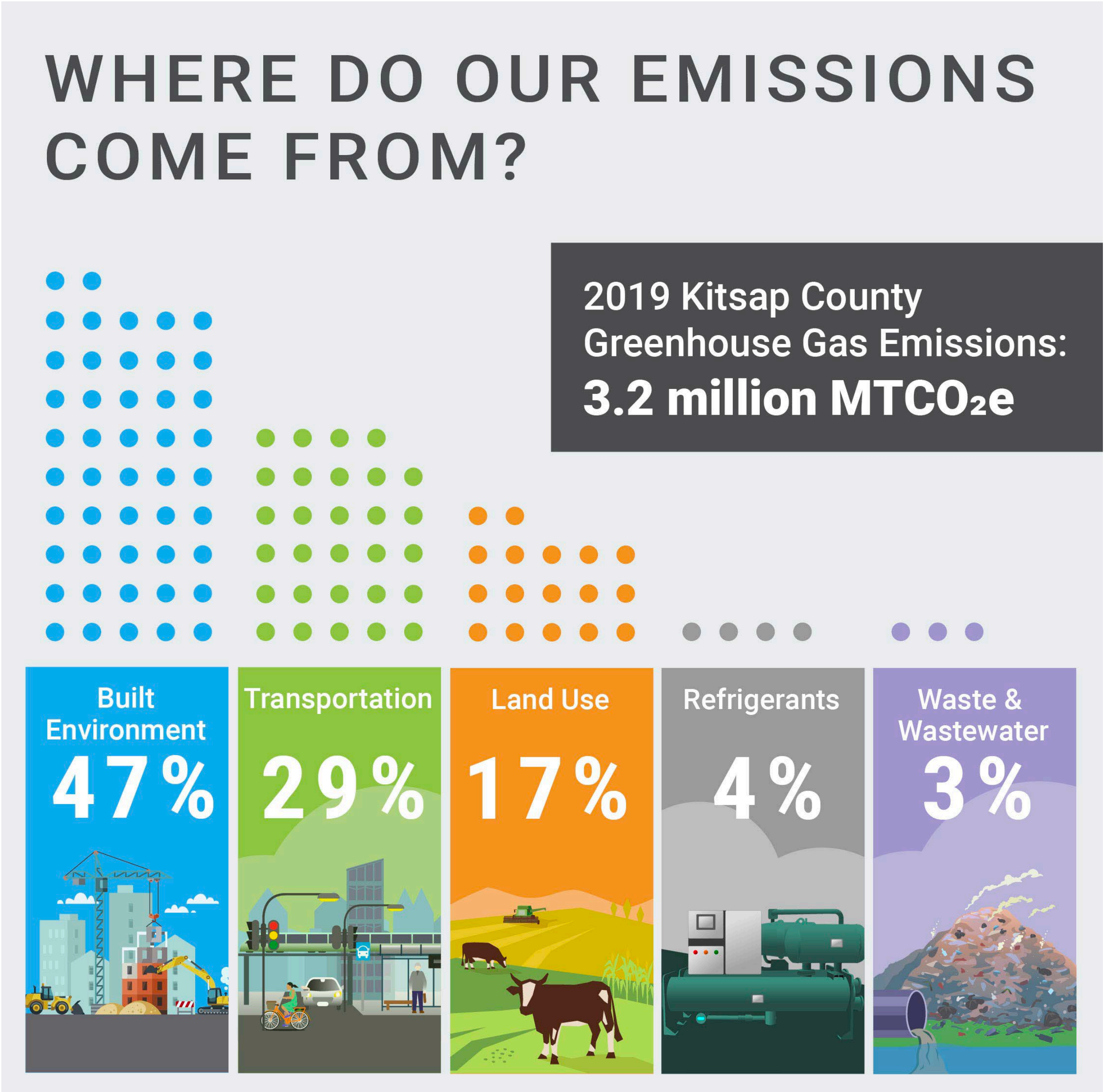


Figure 2. Total greenhouse gas emissions trends over time, by sector.

HOW ARE OUR EMISSIONS CHANGING OVER TIME?

From 2015 to 2019, Kitsap County increased overall emissions by about 16%. While population increased 5% during this same period, per capita emissions increased by 11%.

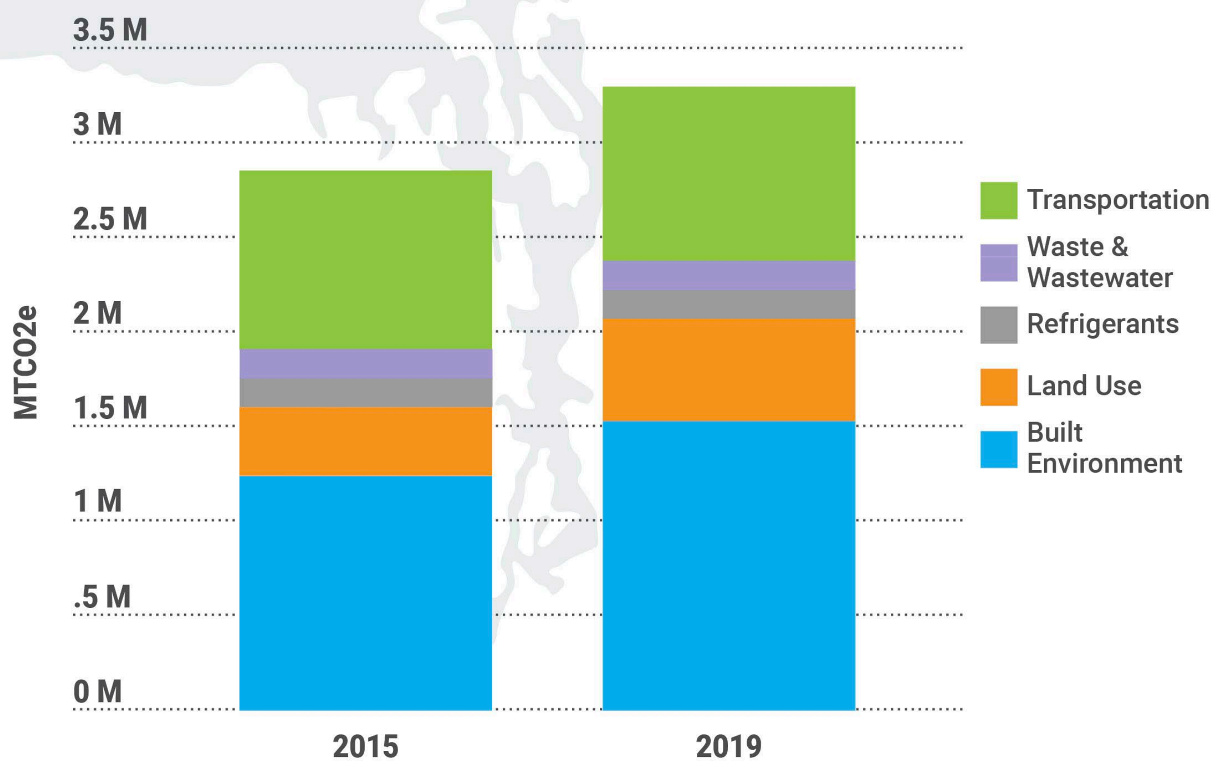
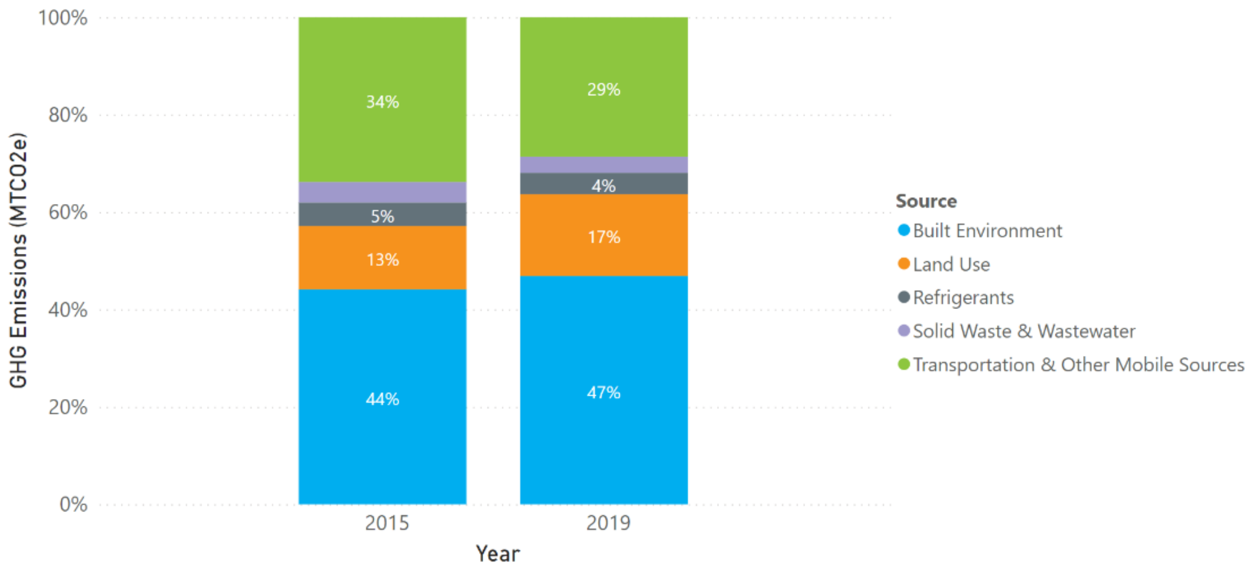


Figure 3. Relative contributions of greenhouse gas emissions, by sector.



Contribution Analysis Findings

A contribution analysis allows jurisdictions to discover the main drivers behind changes in emissions between two inventories conducted at separate points in time. This contribution analysis for 2015–2019 emissions explores the drivers behind the changes in Kitsap County's geographic emissions between these years. The 2015 emissions inventory has been updated using the latest methodology, so 2015 values may differ from those previously reported.

In 2015, total emissions in Kitsap County were 2.8 million $MTCO_2e$, and in 2019, total emissions were 3.2 million $MTCO_2e$, a 16% increase (+0.4 million $MTCO_2e$) from 2015. Figure 44 shows some of the drivers that resulted in increases and decreases of emissions over this period. Some key findings include:

- Emissions increases are primarily driven by tree loss, electricity fuel mix, and growth in population.
- Increased efficiency of passenger vehicles (decreased emissions per mile) was the largest single contributor to decreasing emissions.
- Reduced commercial transportation emissions and more efficient electricity use by households and natural gas use by commercial entities also contributed significantly to decreasing emissions.

Figure 4. Top contributions to change between the 2015 and 2019 GHG inventories.

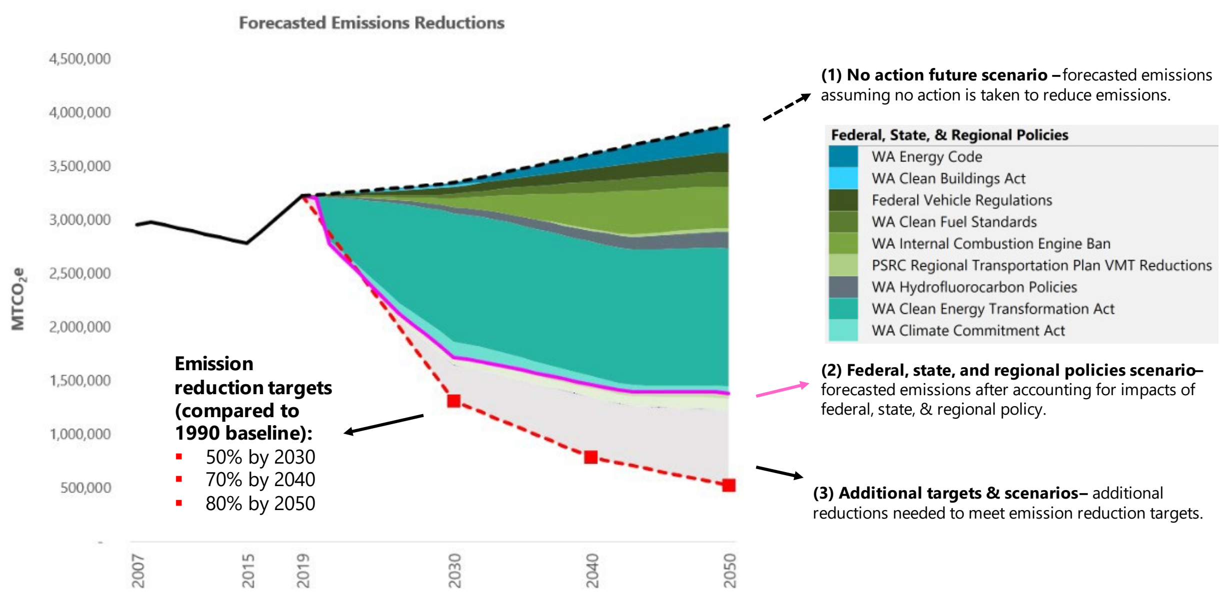
Wedge Analysis Findings

The wedge analysis forecasts emissions from 2019 through 2050 under the following scenarios: 1) no action future; 2) federal, state, and regional policies; and 3) additional targets/reductions. This wedge analysis covers all geographic-based Kitsap County community-scale emissions sources.

As depicted in Figure 26, action by industries, governments, businesses, and individuals will be needed to achieve climate targets.[1] Specifically, the wedge analysis revealed the following projections compared to 1990 baseline GHG emissions levels:

- Under a **no-action future**, we estimate that Kitsap County GHG emissions will increase 48% by 2050.
- We estimate that **existing federal, state, and regional policies** will reduce Kitsap County's GHG emissions by 47% by 2050.
- **Additional reductions** will be needed to acehive a 50% reduction by 2030, 70% reduction by 2040, and 80% reduction by 2050.

Figure 5. Forecasted emissions and reductions under three scenarios.



[1] Kitsap County has not yet committed to reduction targets; targets presented here are hypothetical.

Acronyms

ACS	American Community Survey
BAU	Business as usual
BOD	Biochemical oxygen demand (a metric of the effectiveness of wastewater treatment plants)
CNG	Cascade Natural Gas
CO_2e	Carbon dioxide equivalent
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
ICLEI	ICLEI – Local Governments for Sustainability
kWh	Kilowatt-hour
LTO	Landing and takeoff
MOVES	Motor Vehicle Emission Simulator model (developed by EPA to quantify emissions from mobile sources)
MSW	Municipal solid waste
$MTCO_2e$	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

Afforestation	The act or process of establishing trees or a forest, especially on land not previously forested.
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 greenhouse gases that are not produced intentionally by a stack or vent and can include leaks from industrial plants and pipelines. Fugitive emissions may be caused by the production, processing, transmission, storage, and use of fuel (IPCC, 2006).
Greenhouse gas (GHG)	A gas that absorbs and emits radiant energy within the thermal infrared range, causing the greenhouse effect. Primary greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (e.g., HFCs).
Ozone-depleting substances	Compounds that contribute to stratospheric ozone depletion, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Many of these compounds have recently been substituted with hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), which are not ozone depleting, but are potent greenhouse gases.
Switchgear insulation	The environment within switchgears that are used in electricity transmission systems. Sulfur hexafluoride (SF6), a potent greenhouse gas, is often used in switchgears due to its excellent insulation properties.
Upstream or "lifecycle" GHG emissions	Greenhouse gas (GHG) emissions associated with 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.

Introduction

GHG inventories allow communities to account for sources and quantities of GHG emissions generated by community activities. The **geographic inventory** estimates the annual GHG emissions released within community boundaries plus those associated with certain activities, such as electricity consumption and waste disposal.

The **geographic inventory** estimates GHG emissions produced by activities of the Kitsap County community, including emissions resulting from community energy use; wastewater and solid waste processing; and land use practices. It includes both "in-boundary" emission *sources*—any physical process inside the jurisdictional boundary that releases GHG emissions—and activities resulting in GHG emissions. For example, it includes emissions associated with the in-county *production* of food and goods, regardless of where those goods are consumed, such as from a manufacturer located within Kitsap County that produces goods for export.

This inventory report includes a new communitywide 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 Kitsap County Emissions Come From?** Describes methodologies and results for the geographic-plus inventory.
- **What's Driving Kitsap County Emissions Trends?** Explores drivers of Kitsap County emission trends.
- **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 countywide climate goals.
- **Appendix A. Inventory Methodology** provides a detailed summary of the geographic inventory methodology, including key data sources and assumptions.

Where Do Kitsap County Emissions Come From?

Geographic Inventory Approach

The 2019 Kitsap County 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*. Inventory data was gathered for the 2019 calendar year and accounts for emissions from the activities of Kitsap County residents, businesses, employees, and visitors undertaken within or originating from within the county limits. 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	**Building Energy**
Driving within county limits, flights from county travelers, maritime/rail travel, non-road vehicle and equipment use	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	**Refrigerants**
Solid waste generation and disposal and wastewater processes	Substitution of ozone-depleting substances
Land Use	**Sequestration**
Agriculture and tree cover loss	Solid waste disposal sequestration and sequestration from trees and forests

What is a communitywide geographic GHG emissions inventory?

A communitywide geographic GHG emissions inventory quantifies the annual emissions produced within community boundaries due to community activities, such as on-road transportation and energy consumption. A geographic emissions inventory does not account for upstream emissions from goods and services consumed within the community, such as food or furniture.

This is different from Kitsap County's consumption-based inventory, 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, the consumption-based inventory would not include GHG emissions associated with the production of goods from a local manufacturer that are consumed entirely outside the community, but would include GHG emissions associated with the production of goods manufactured in another community but consumed within Kitsap County. Thus, the consumption-based inventory accounts for different, but related sources of emissions associated with community activities.

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

Inventory Summary

- In 2019, Kitsap County's residents, businesses, employees, and visitors produced 3.2 million metric tons of CO_2 equivalent ($MTCO_2e$) (Figure 65).
- This equates to roughly 12 $MTCO_2e$ per capita in 2019 (Table 2).
- Total GHG emissions in 2019 increased 16% compared to the last inventory year (2015; Figure 76).
- Per-capita GHG emissions in 2019 increased 11% compared to 2015 (Figure 87).
- The largest GHG emissions sources are building electricity (~34%), onroad transportation (~18%), and tree loss (~15%) (Figure 65).

Figure 6. Sources of greenhouse gas emissions for Kitsap County in 2019.

Total = 3.2 million $MTCO_2e$

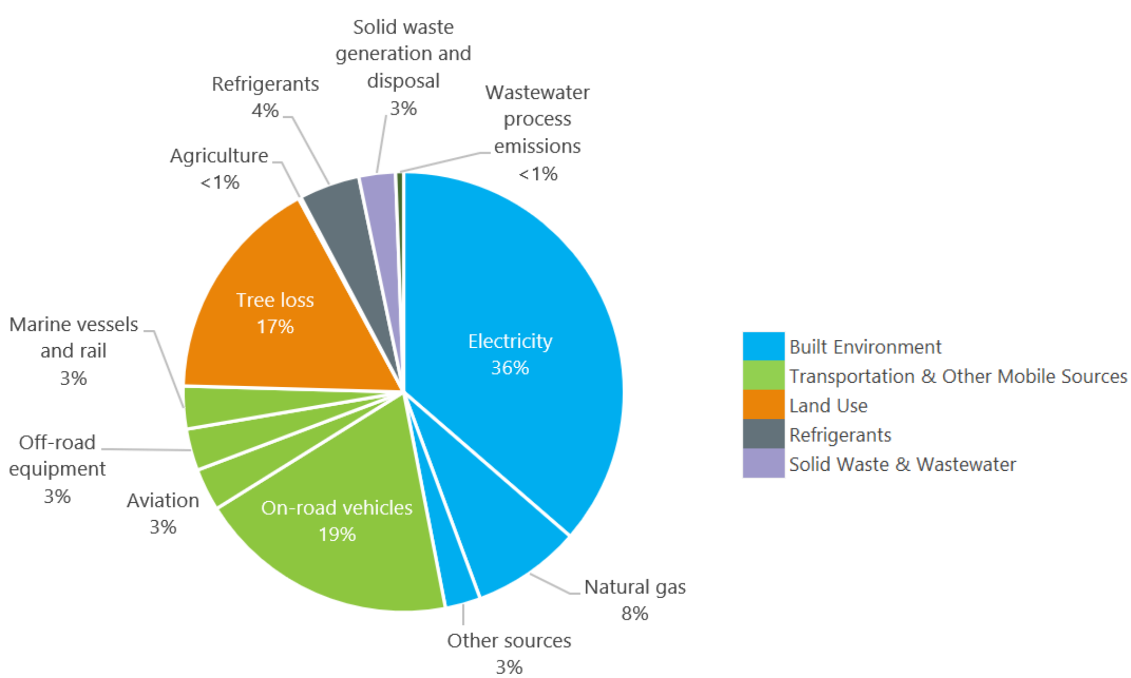


Figure 7. Greenhouse gas emissions trends over time, by sector.

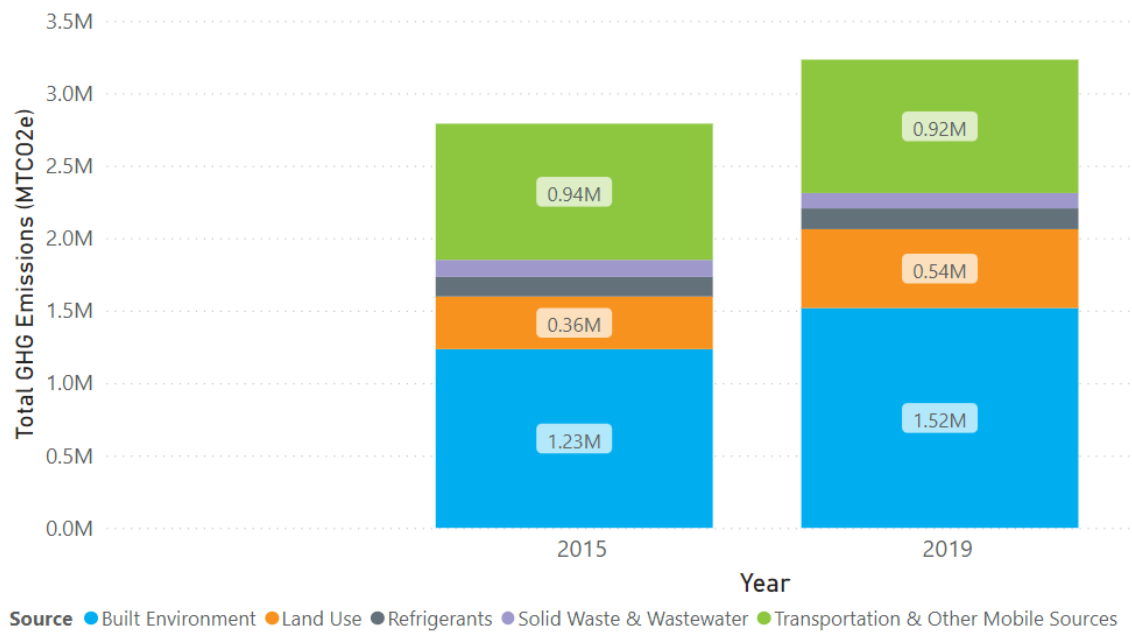


Figure 8. Per-capita greenhouse gas emissions trends over time, by sector.

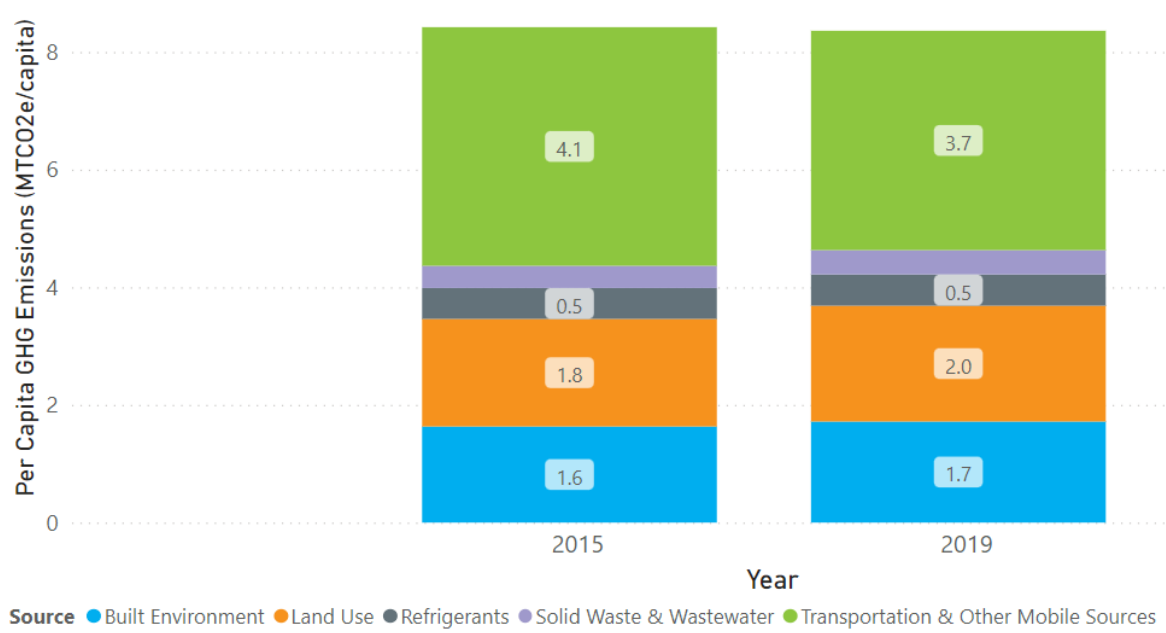


Figure 9. Comparison of per-capita GHG emissions from all sectors across jurisdictions.[2]

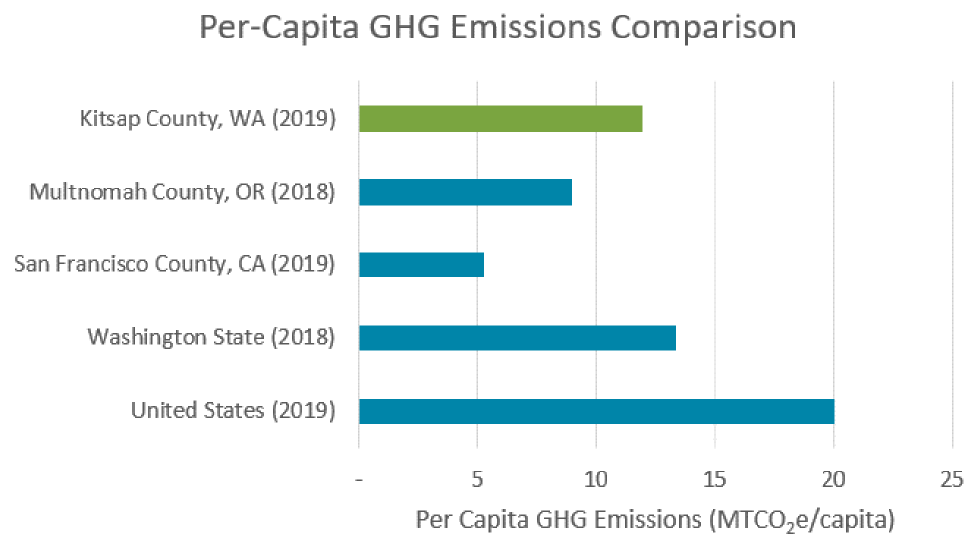
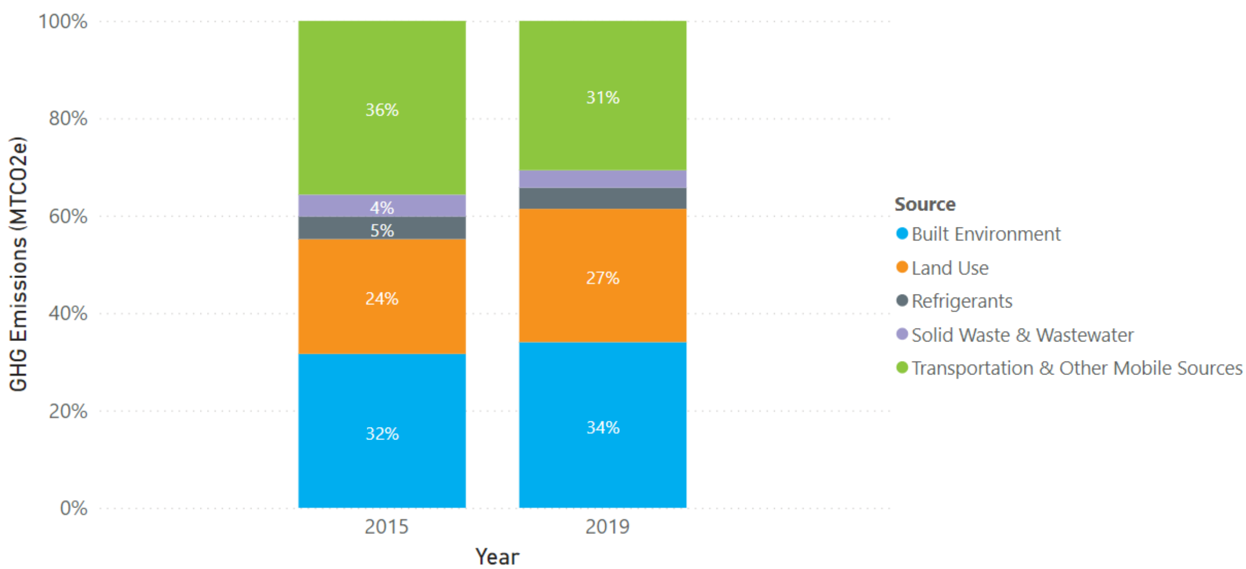


Figure 10. Relative contributions of greenhouse gas emissions, by sector.



[2] Included emissions sources vary by jurisdiction.

Table 1. Communitywide geographic GHG emissions, by sector and year ($MTCO_2e$). Grey boxes indicate key emissions sources that are typcially required under GHG inventory protocols.

GHG Emissions by Sector ($MTCO_2e$)	2015	2019
Built Environment	**1,234,151**	**1,517,808**
Electricity	**950,505**	**1,175,620**
Residential	609,750	745,027
Commercial	336,154	424,904
Industrial	4,601	5,689
Natural gas	**205,031**	**258,151**
Residential	94,200	118,232
Commercial	106,694	134,934
Industrial	4,137	4,985
Other sources	**78,615**	**84,037**
Fuel oil	34,962	27,917
Residential propane	41,340	54,743
Industrial processes	2,313	1,377
Transportation and Other Mobile Source	**939,923**	**920,711**
On-road vehicles	**674,721**	**619,457**
Passenger vehicles	600,778	538,664
Freight and service vehicles	67,766	75,040
Transit vehicles	6,177	5,753
Aviation	**83,237**	**100,672**
Off-road equipment	**95,945**	**99,071**
Marine & rail	**86,020**	**101,511**
Solid Waste & Wastewater	**117,890**	**105,831**
Solid waste generation & disposal	**100,878**	**86,781**
Landfill	100,878	83,496
Compost	-	3,285
Wastewater process emissions	**17,012**	**19,050**
Refrigerants	**135,528**	**143,674**
Refrigerants	**135,528**	**143,674**
Land Use	**362,900**	**544,333**
Agriculture	**6,900**	**6,333**
Tree loss	**356,000**	**538,000**
Total Emissions	**2,790,392**	**3,232,357**
Subset: Basic Activities	1,941,970	2,153,306

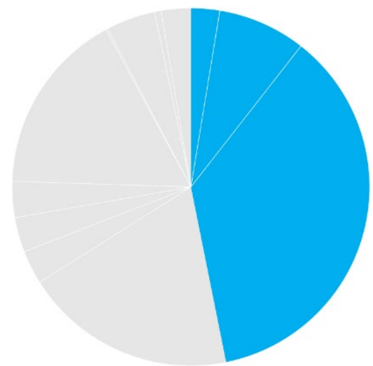
Table 2. Per-capita geographic GHG emissions, by year ($MTCO_2e$). Grey boxes indicate key emissions sources that are typcially required under GHG inventory protocols.

GHG Emissions by Sector ($MTCO_2e$/capita)	2015	2019
Built Environment	**4.8**	**5.6**
Electricity	**3.7**	**4.4**
Residential	2.4	2.8
Commercial	1.3	1.6
Industrial	0.0	0.0
Natural gas	**0.8**	**1.0**
Residential	0.4	0.4
Commercial	0.4	0.5
Industrial	0.0	0.0
Other sources	**0.3**	**0.3**
Residential fuel oil	0.1	0.1
Residential propane	0.2	0.2
Industrial processes	0.0	0.0
Transportation and Other Mobile Sources	**3.6**	**3.4**
On-road vehicles	**2.6**	**2.3**
Passenger vehicles	2.3	2.0
Freight and service vehicles	0.3	0.3
Transit vehicles	0.0	0.0
Aviation	**0.3**	**0.4**
Off-road equipment	**0.4**	**0.4**
Marine & rail	**0.3**	**0.4**
Solid Waste & Wastewater	**0.5**	**0.4**
Solid waste generation & disposal	**0.4**	**0.3**
Landfill	0.4	0.3
Compost	-	0.0
Wastewater process emissions	**0.1**	**0.1**
Refrigerants	**0.5**	**0.5**
Refrigerants	**0.5**	**0.5**
Land Use	**1.4**	**2.0**
Agriculture	**0.0**	**0.0**
Tree loss	**1.4**	**2.0**
Total Emissions	**10.8**	**12.0**
Subset: Basic Activities	7.5	8.0

Inventory Findings, By Sector

Built Environment

Summary



- In 2019, the built environment accounted for 47% of communitywide emissions.
- Emissions from electricity and natural gas accounted for most of those emissions and 44% of *all* emissions in 2019.
- Built environment emissions in 2019 increased 23% since 2015.
- Primary contributors to this change include changes in electricity and natural gas consumption, in part due to population increases, and a higher carbon intensity (emissions per unit of energy produced) of PSE's fuel mix.
- Industrial process emissions account for less than 1% of total communitywide emisions in 2019, and these emissions have decreased 40% since 2015.

Electricity

Kitsap County's electricity is delivered through Puget Sound Energy (PSE). Electricity accounted for 36% of Kitsap County's total communitywide GHG emissions in 2019. **Electricity emissions in 2019 increased 24%** since 2015. These changes in electricity emissions can be attributed to changes in electricity consumption (Figure 1211) and the carbon intensity of utility electricity fuel sources (Figure 1312).

Figure 11. Electricity emissions trends, by sector.

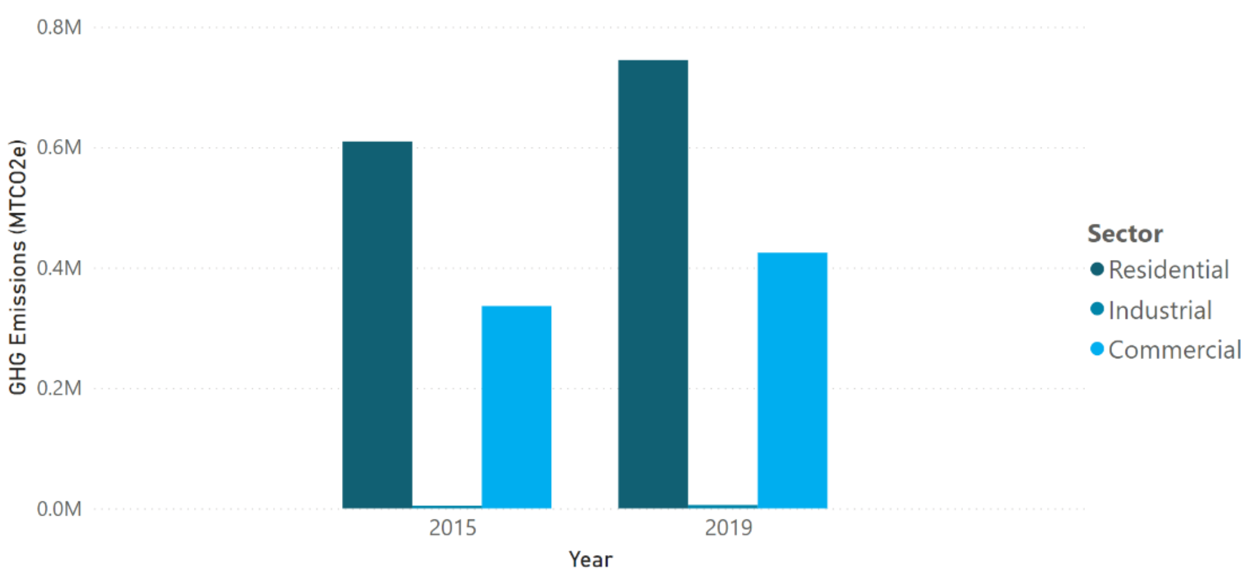


Figure 12. Electricity consumption trends, by sector.

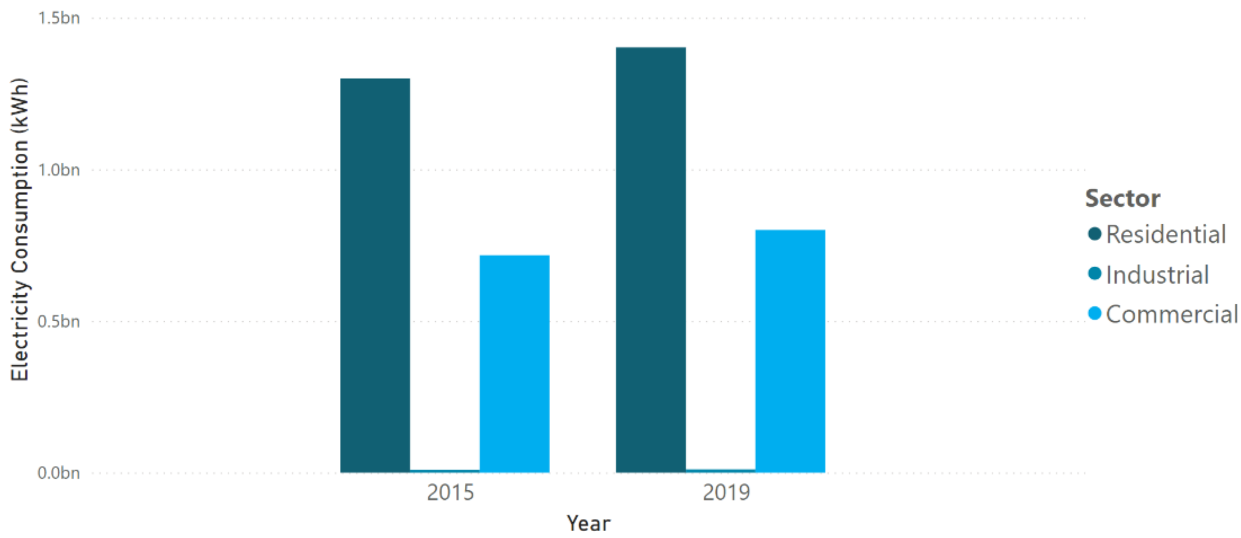
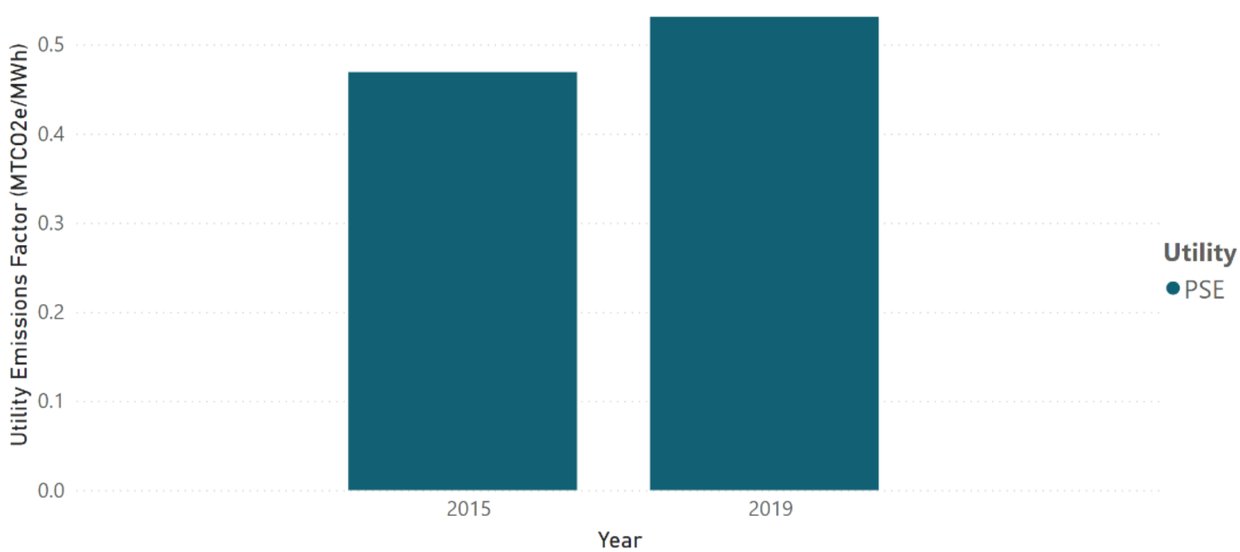


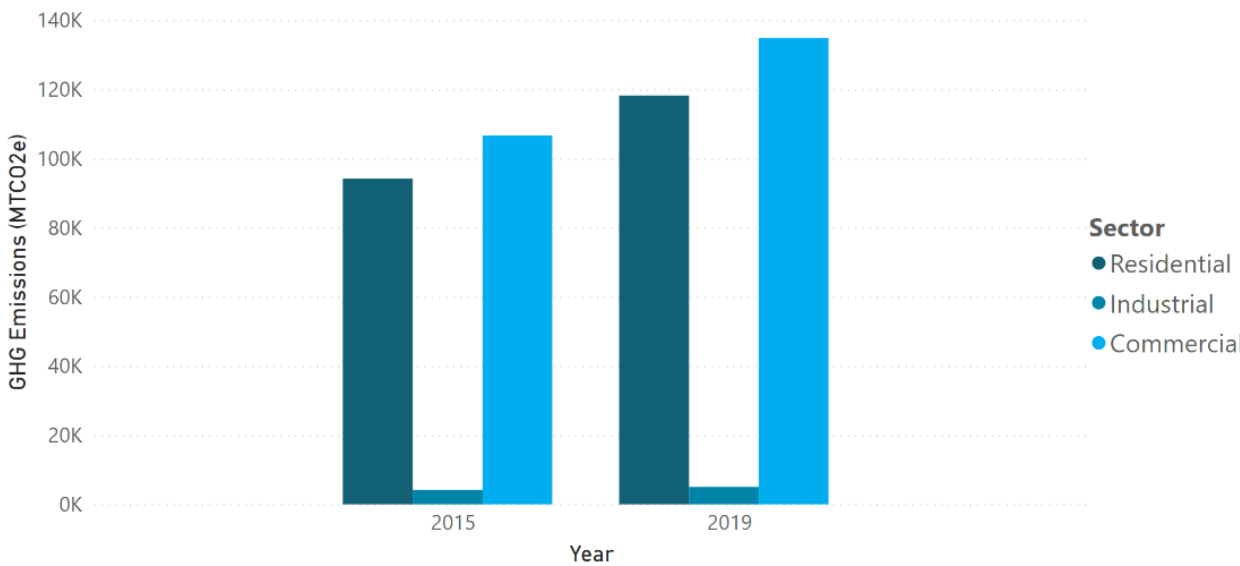
Figure 13. Electricity carbon intensities for Kitsap County electricity utility.



Natural Gas

Kitsap County's natural gas is delivered by Cascade Natural Gas (CNG). **Natural gas accounted for 8% of Kitsap County's total communitywide GHG emissions** in 2019. Natural gas emissions in 2019 increased 26% since 2015, partially due to an increased demand for heating fuels and electricity because of colder winter weather in 2019.

Figure 14. Natural gas emissions trends, by sector.



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 3% of the 2019 inventory.

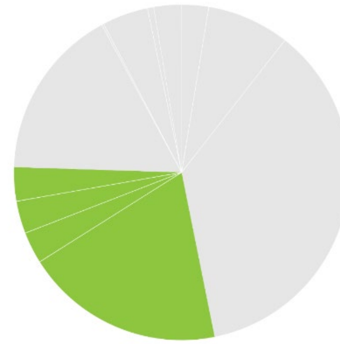
Fuel oil emissions in 2019 decreased 20% from 2015, driven by a decrease in the overall consumption of fuel oil.

Residential propane emissions, however, increased 32% in 2019 from 2015. Emissions from residential propane account for around 2% of all Kitsap County emissions. This increase was driven primarily by a substantial (44%) increase in propane sales across the West Coast.

Industrial process emissions in 2019 decreased 40% compared to 2015. These trends were driven primarily by a substantial decrease (-83%) in industrial emissions from the county's highest emitting facility.

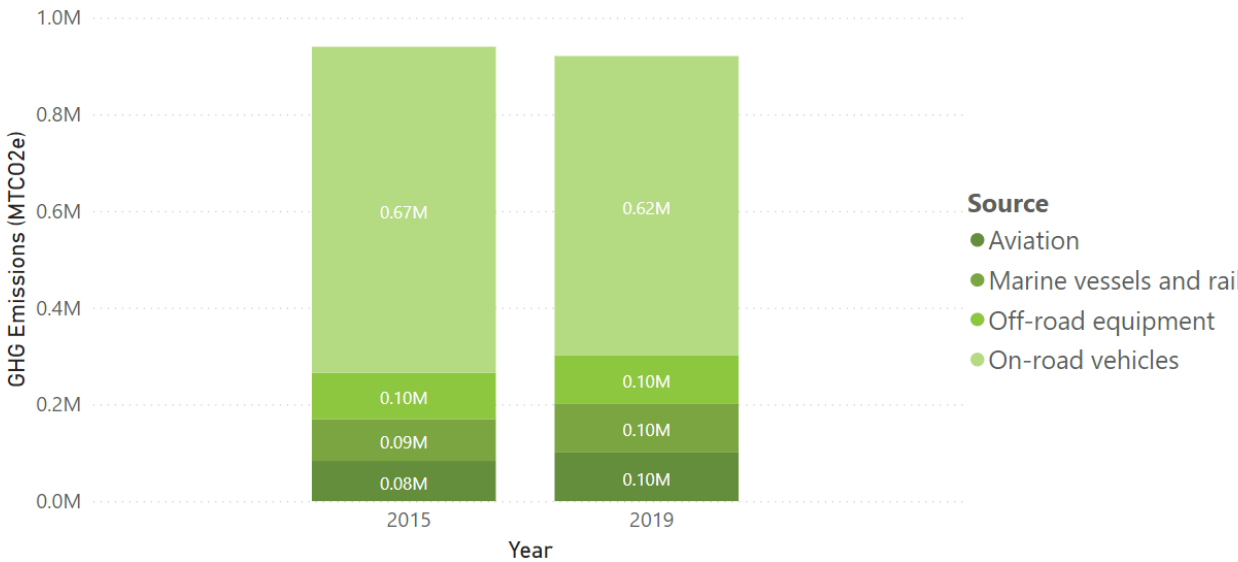
Transportation

Summary



- In 2019, transportation accounted for 29% of communitywide emissions.
- Emissions from onroad passenger and freight travel accounted for most of those emissions and 19% of *all* emissions in 2019 (Figure 1514).
- Total and per-capita onroad passenger vehicle transportation emissions in 2019 are estimated to have decreased 10% and 14% since 2015, respectively. Emissions from freight and service vehicle transportation have increased 11% since 2015.
- Transportation emissions in 2019 have decreased 2% since 2015. While the average vehicle fuel efficiency has improved, Kitsap County has seen an increase in VMT (overall and per-capita).
- Aviation emissions in 2019 accounted for 3% of total communitywide emisions and have increased 21% since 2015.

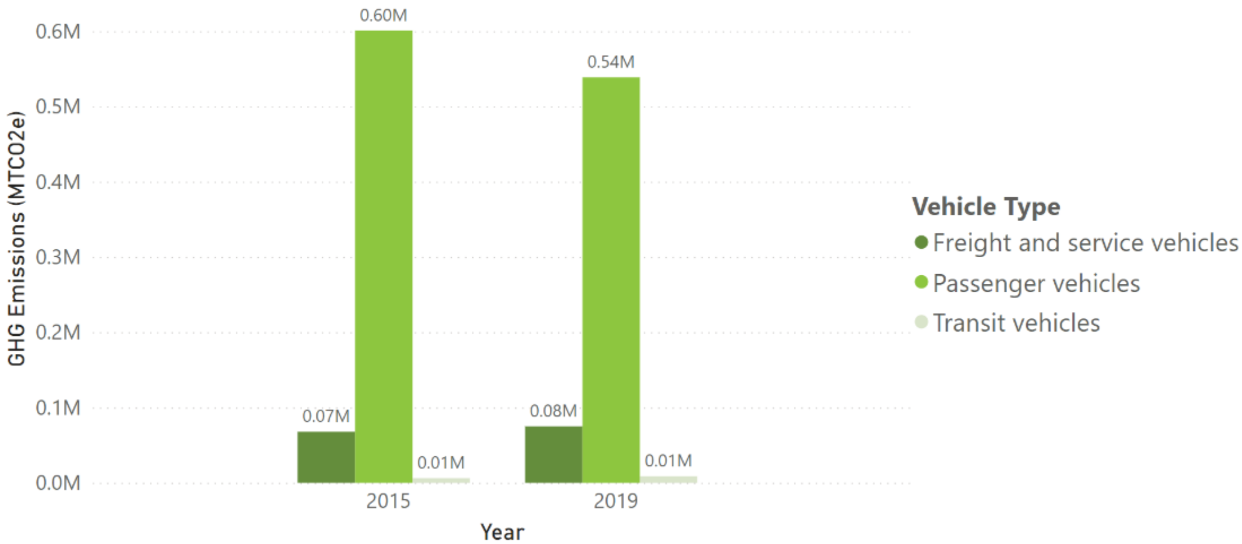
Figure 15. Transportation emissions trends, by sector.



Onroad Transportation

Onroad transportation emissions include those from passenger vehicles, freight trucks, and transit vehicles within the county boundary. **Onroad tranportation activities accounted for 19% of Kitsap County's total communitywide GHG emissions** in 2019. Total onroad emissions in 2019 decreased 8% since 2015 (Figure 1615). While the average vehicle fuel efficiency has improved, Kitsap County has seen an increase in VMT (overall and per-capita).

Figure 16. Onroad transportation emissions trends, by 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 better quantify the full magnitude of GHG emissions associated with air travel to and from Kitsap County, four separate approaches were used as part of this project to quantify the impact of this sector:

- A **LTO analysis**, estimating only emissions that occur within Kitsap County.
- A **passenger-based approach**, looking at all aviation fuel sold in the Puget Sound region and attributable to Kitsap County residents or visitors.
- **All fuels** sold at airports located within Kitsap County.
- A **consumption-based approach**, estimating aviation emissions from Kitsap County residents that may occur anywhere in the world.

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

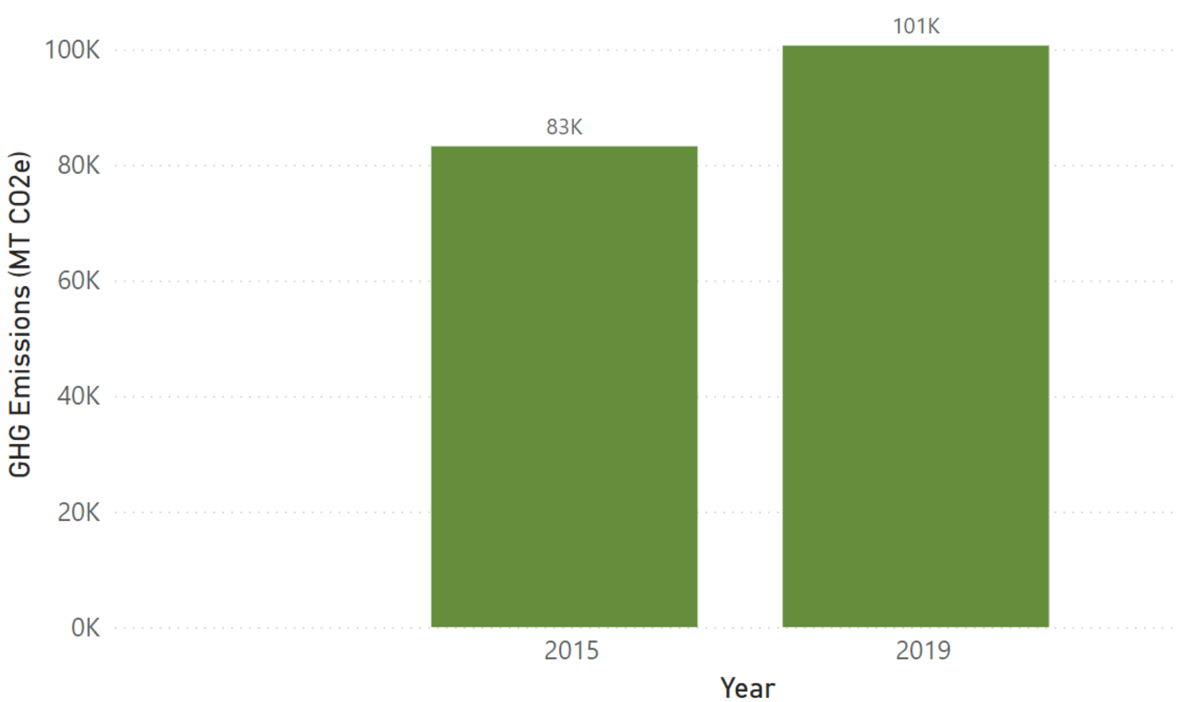
Table 3. County aviation sector GHG emissions for the 2019 calendar year.

Approach	Description	Per Capita ($MTCO_2e$)	Total ($MTCO_2e$)
Landing and takeoff only	**Locally generated emissions associated with airplane takeoff and landing** (incomplete, historic method recommended by local government GHG protocols, 10% of "all fuels" approach)	N/A	0 (no data obtained from local airports)

Approach	Description	Per Capita ($MTCO_2e$)	Total ($MTCO_2e$)
Passenger-based	**Total attributable to Kitsap County residents, employees, and visitors** (total included in geographic inventory)	0.4	101,000 (total proposed for geographic "wedge analysis", ~3% of total geographic inventory)
All fuels	**All fuels sold at local airports** (no matter the user)	N/A	0 (no data obtained from local airports)
Consumption-based	**Personal air travel by Kitsap County residents** (emissions occur worldwide; excludes some work travel; excludes travel associated with residents that live outside Kitsap County; uses lifecycle GHG coefficient)	1.4 (per household)	152,000

Using the passenger-based emissions method, aviation is estimated to have accounted for 3% of Kitsap County's total communitywide GHG emissions in 2019. Findings using this method are presented in the summary graphics for this inventory because they more comprehensively reflect the full GHG emissions associated with air travel due to County resident and business activities. In 2019, aviation emissions increased 21% from 2015, driven by a combination of population and economic growth.

Figure 17. Aviation emissions trends using the passenger-based estimation method.



Other Sources

The remaining 6% 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 3% compared to 2015.

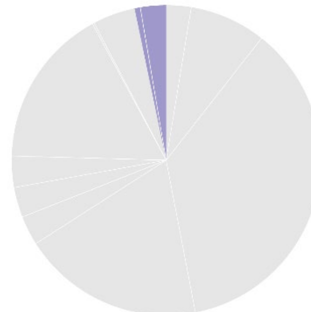
Overall, emissions from marine vessels and rail have increased 18% since 2015. This category includes emissions from ferries and maritime OGV (ocean-going vessel—shipping).

Emissions from ferries have increased 13% since 2015, and emissions from maritime ocean-going vessels have increased 25% since 2015. These emissions were scaled using vessel calls as identified in Port annual reports. There was an increase in the number of vessels calls since 2015, primarily through the Northwest Seaport Alliance.

Drivers of these trends also include the North American Emission Control Area (ECA), which came into effect in 2015 and requires vessels to use sustainable fuels near the coast, and an increase in the use of shore power.

Solid Waste & Wastewater

Summary



- In 2019, solid waste disposal & wastewater treatment accounted for 3% of communitywide emissions.
- Emissions from community solid waste disposal to landfill accounted for most of those emissions and about 3% of *all* emissions, respectively.
- Solid waste emissions in 2019 decreased 14% compared to 2015. Contributors to this change include a reduction in overall organic waste generation and landfilled waste (Figure 1818).
- Wastewater emissions increased 12% between 2015 and 2019.

Solid Waste

Solid waste emissions include those from landfilling and commercial composting of solid waste generated by the Kitsap County community. Although Kitsap County does not have a landfill within its borders, this inventory accounts for the GHG emissions associated with waste that is generated within Kitsap County but processed outside County borders. 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 released, 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 close to 3% of Kitsap County's total communitywide GHG emissions in 2019. **Overall, solid waste emissions decreased 14% since 2015, driven by reductions in tons of waste sent to landfill** (Figure 1818 and Figure 1919).

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

Figure 18. Solid waste emissions trends, by sector.

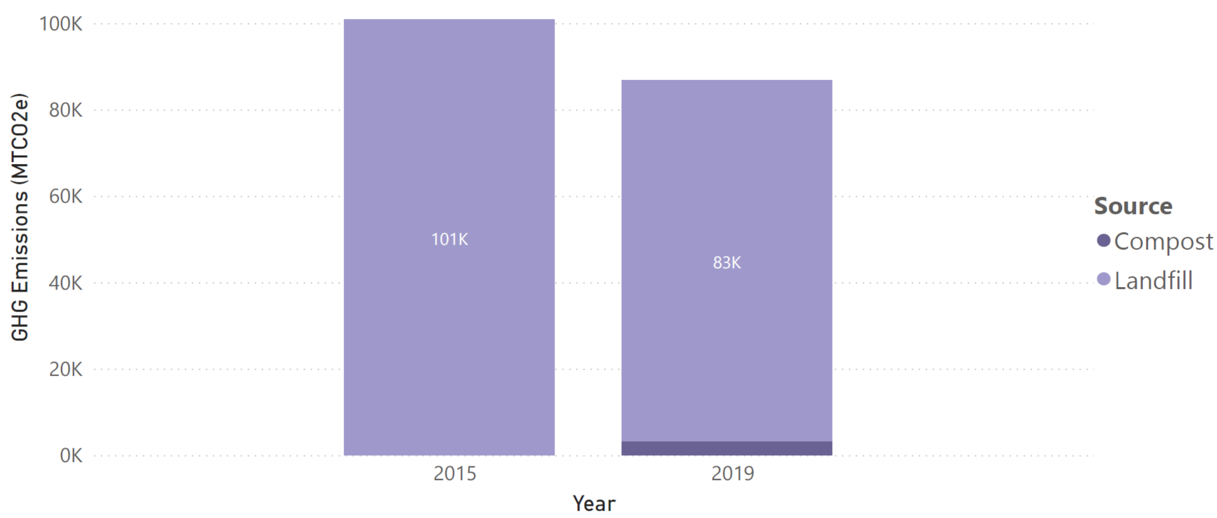
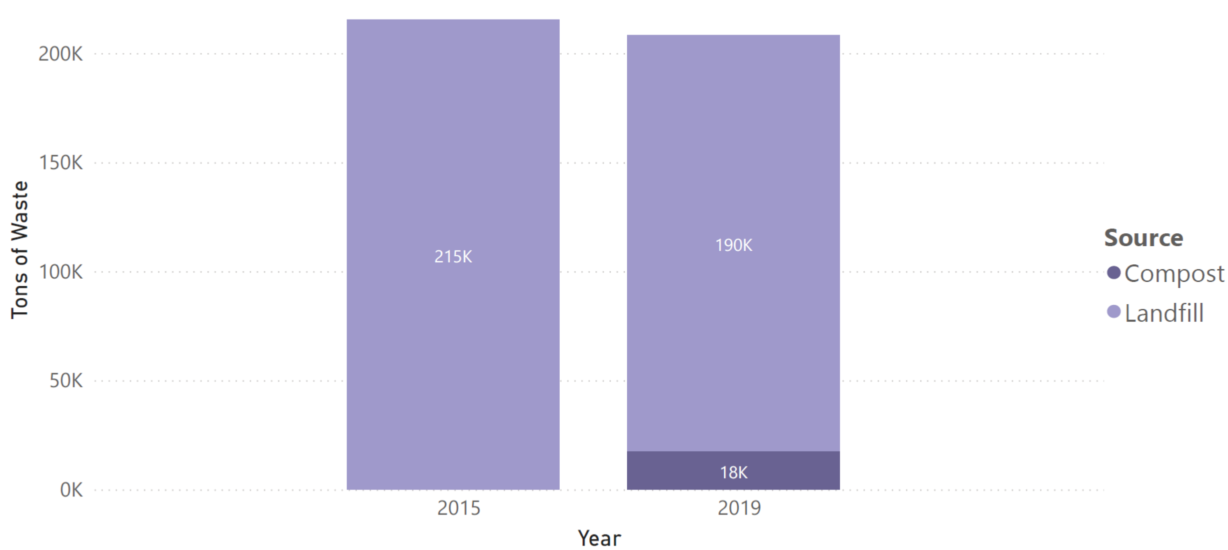


Figure 19. Solid waste tonnage trends, by sector.[3]



Wastewater

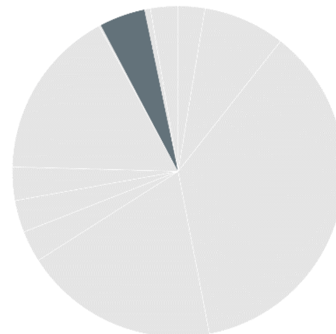
Kitsap County's emissions from wastewater have **increased** 12% since 2015. This increase is tied primarily to a growing population, as well as emissions from the combustion of digester gas at the Central Kitsap Treatment Plant. The plant's new digester gas cogeneration system was not installed until the fall of 2015 as part of the plant's Resource Recovery & Process Improvement Project, so these emissions were not included in the 2015 inventory (Kitsap County, 2015).

[3] Composting emissions were not calculated in 2015 due to data limitations.

Kitsap 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.

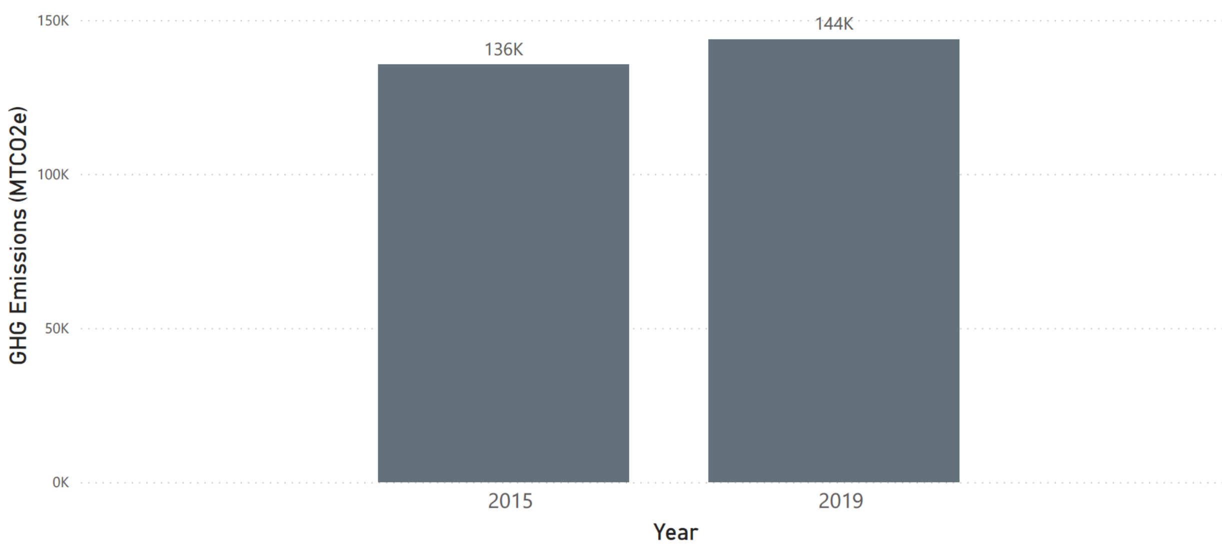
Refrigerants

Summary



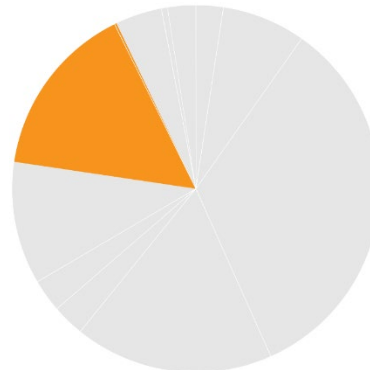
- Refrigerant emissions stem primarily from the release of hydrofluorocarbons (HFCs), which are a substitution for ozone depleting substances (ODSs). HFCs, which are greenhouse gases, are mainly used for air conditioning and refrigeration equipment (USEPA, 2014).
- In 2019, refrigerants accounted for 4% of communitywide emissions.
- Refrigerant emissions have increased 6% since 2015 (Figure 2020).
- Refrigerant emissions are estimated by downscaling national-level refrigerant emission data to the local level based on population. Therefore, trends in this source are a product of both national-level refrigerant trends and local population growth.

Figure 20. Refrigerant emissions trends.



Land Use

Summary



- Land use emissions stem from agriculture and tree cover loss.
- In 2019, land use accounted for 17% of communitywide emissions.
- Land use emissions have increased 50% from 2015, driven by an increase in acres of tree loss and increased emissions associated with tree loss in 2019.

Agriculture

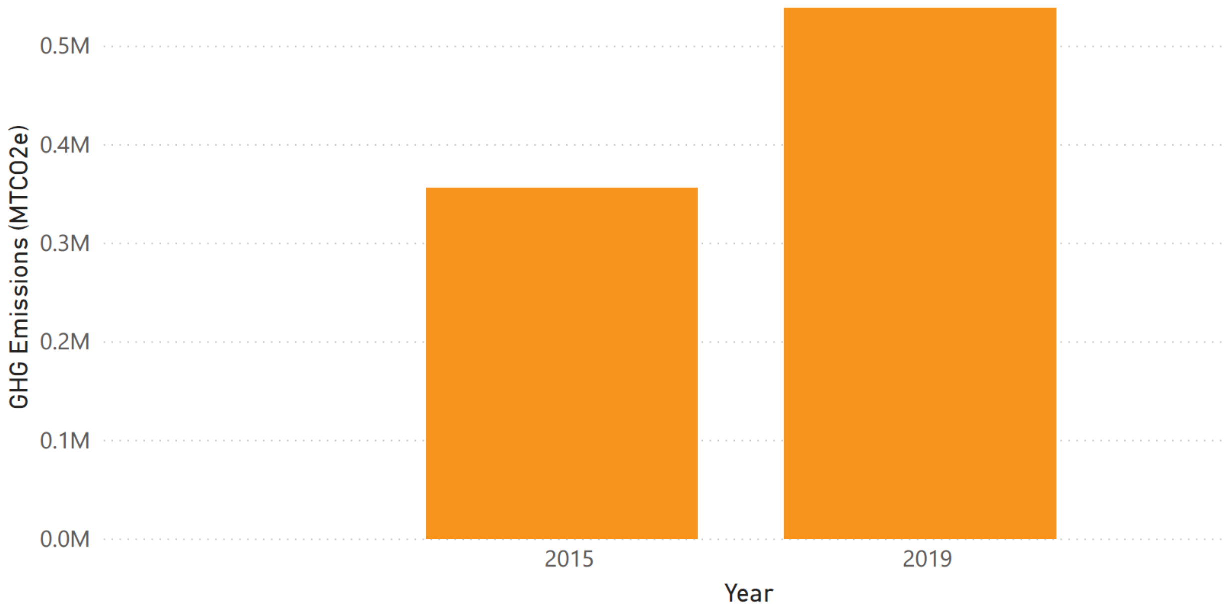
Agriculture accounts for less than 1% of GHG emissions in Kitsap County, and this relative contribution has remained steady over time. Emissions are primarily derived from the release of methane and nitrous oxide emissions associated with livestock digestion (enteric fermentation) and manure management. **Emissions from livestock and manure management** in 2019 **decreased** 7% compared to 2015, likely due to a decrease in the number of beef and dairy cattle, which release more methane than other farm animals. Nitrous oxide emissions from soil have decreased 11% since 2015 due to a decrease in acres of cropland in Kitsap County.

Tree Loss

Deforestation and tree cover loss by other means accounted for an estimated 17% of Kitsap County's total communitywide GHG emissions in 2019. Forests store carbon in tree trunks, roots, leaves, branches, and soil, so when tree cover is lost, that carbon is released into the atmosphere. Overall, **tree cover loss emissions in 2019 increased 51%** 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.

These estimates do not include the carbon sequestration benefits of existing forests or tree planting (afforestation) but represent only the GHG emissions.

Figure 21. Tree loss emissions trends.



Carbon Sequestration

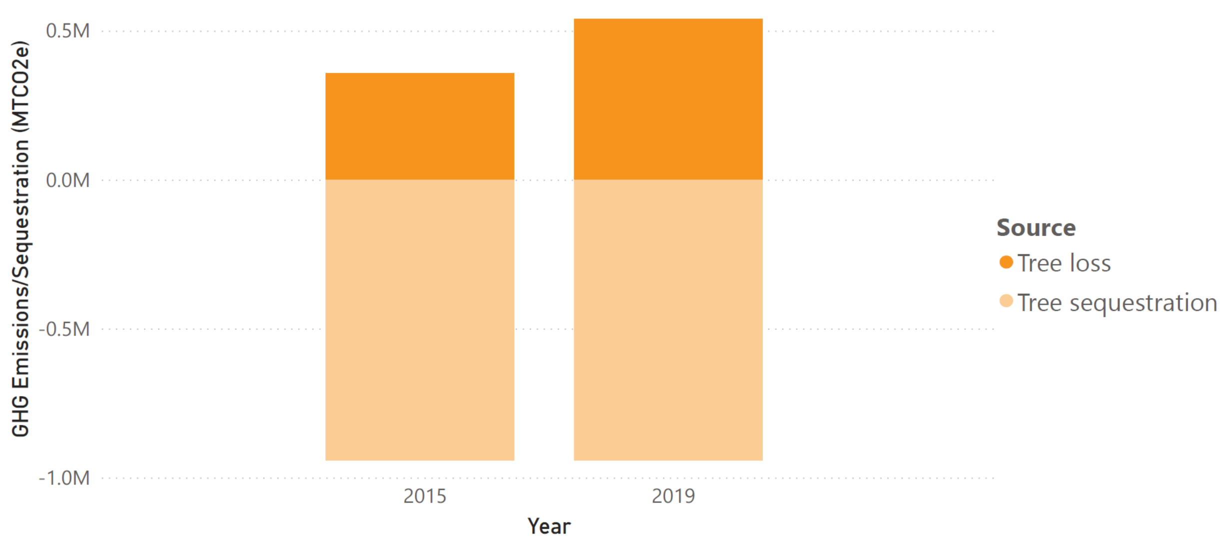
Summary

- Carbon sequestration (removal of CO_2 from the atmosphere) stems from trees removing carbon from the atmosphere and solid waste disposal.
- Total gross carbon sequestration from these sources totals around 1 million $MTCO_2e$ in 2019.
- Contributors to changes in sequestration include net tree loss from development, forest degradation/deforestation, and changes in the tons and composition of organic waste that is landfilled and composted.
- For this inventory, carbon sequestration from trees and forests was averaged over a twenty year period, so annual values do not vary.[4]

Tree Sequestration

Trees and forests in Kitsap County **sequester around 942,000 $MTCO_2e$ per year**. Sequestration estimates are based on a variety of factors, such as the forest type, ecozone, forest age, and number of years of sequestration. Carbon removals were averaged over a twenty-year period because sequestration data was not available as a time series; therefore, sequestration values are the same across years.

Figure 22. Net forest sequestration trends.



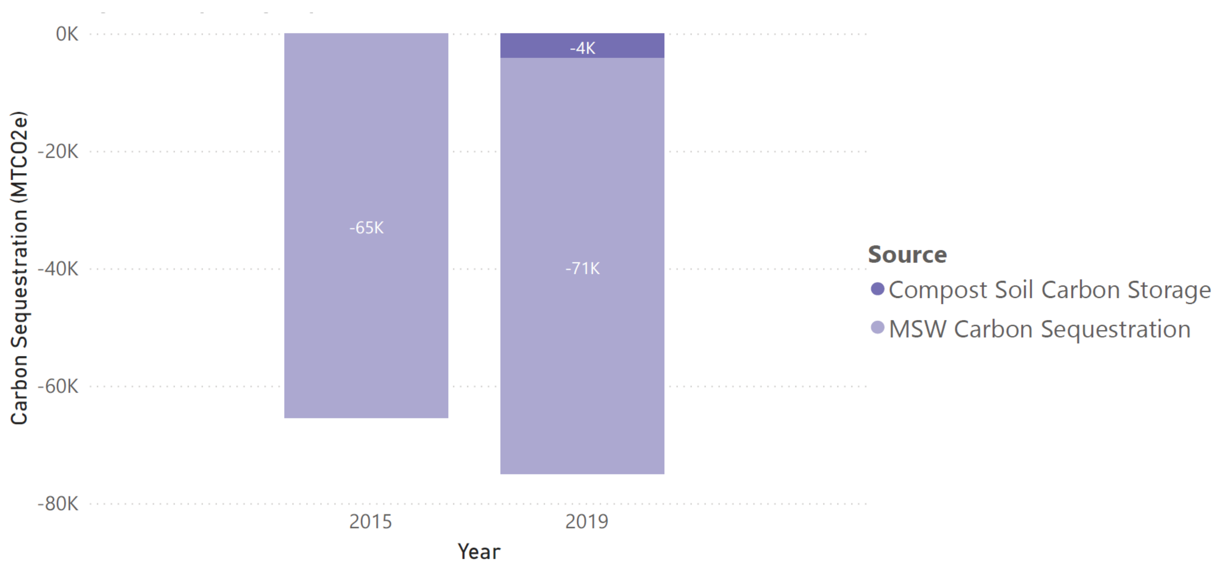
[4] Due to data limitations from the tool utilized for the inventory, World Resource Institute's Global Forest Watch (https://www.wri.org/initiatives/global-forest-watch).

Solid Waste Sequestration

Sequestration from solid waste disposal stems from sequestration of carbon-containing waste products in both landfills and composting systems (e.g., through soil amendments). When organic materials are sent to the landfill, a portion of the carbon that would naturally decompose does not; therefore, aerobic decomposition and the associated emissions are prevented.

In 2019, solid waste disposal sequestered approximately ~75,000 $MTCO_2e$. Solid waste sequestration has increased over time due to changes in the estimated composition of landfilled waste.[5] This geographic-focused analysis does not account for the upstream, lifecycle GHG savings associated with waste diversion.

Figure 23. Landfilling and composting sequestration trends.



[5] Composting emissions were not calculated in 2015 due to data limitations.

What's Driving Kitsap County Emissions Trends?

Contribution Analysis Introduction

A contribution analysis allows jurisdictions to discover the reasons for changes in emissions between two inventories separated in time. This updated contribution analysis for 2015 to 2019 emissions was conducted using the tool available from ICLEI USA.[6]

Results

In 2015, total emissions in Kitsap County were 2.8 million $MTCO_2e$, and in 2019, total emissions were 3.2 million $MTCO_2e$, a 16% increase (+0.4 million $MTCO_2e$) from 2015.

Figure 2424 below provides a summary of the three largest factors increasing emissions and the three largest factors decreasing emissions. The remaining increases and decreases are combined and categorized as “other increases” and “other decreases.”

Emissions increases are primarily driven by tree loss, electricity fuel mix, and growth in population. Increased efficiency of passenger vehicles (decreased emissions per mile) was the largest single contributor to decreasing emissions. Reduced commercial transportation emissions and more efficient electricity use by households and natural gas use by commercial entities also contributed significantly to decreasing emissions.

[6] Available at https://icleiusa.org/ghg-contribution-analysis/.

Figure 24. Top contributions to change between the 2015 and 2019 GHG inventories.

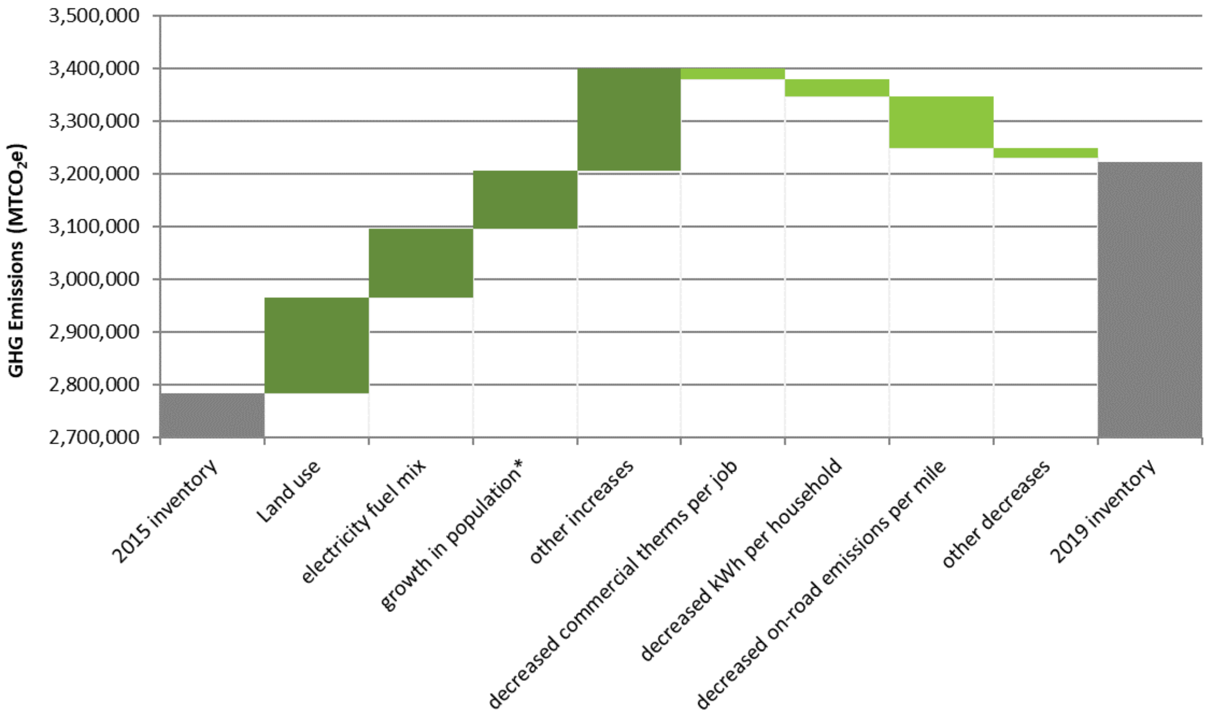
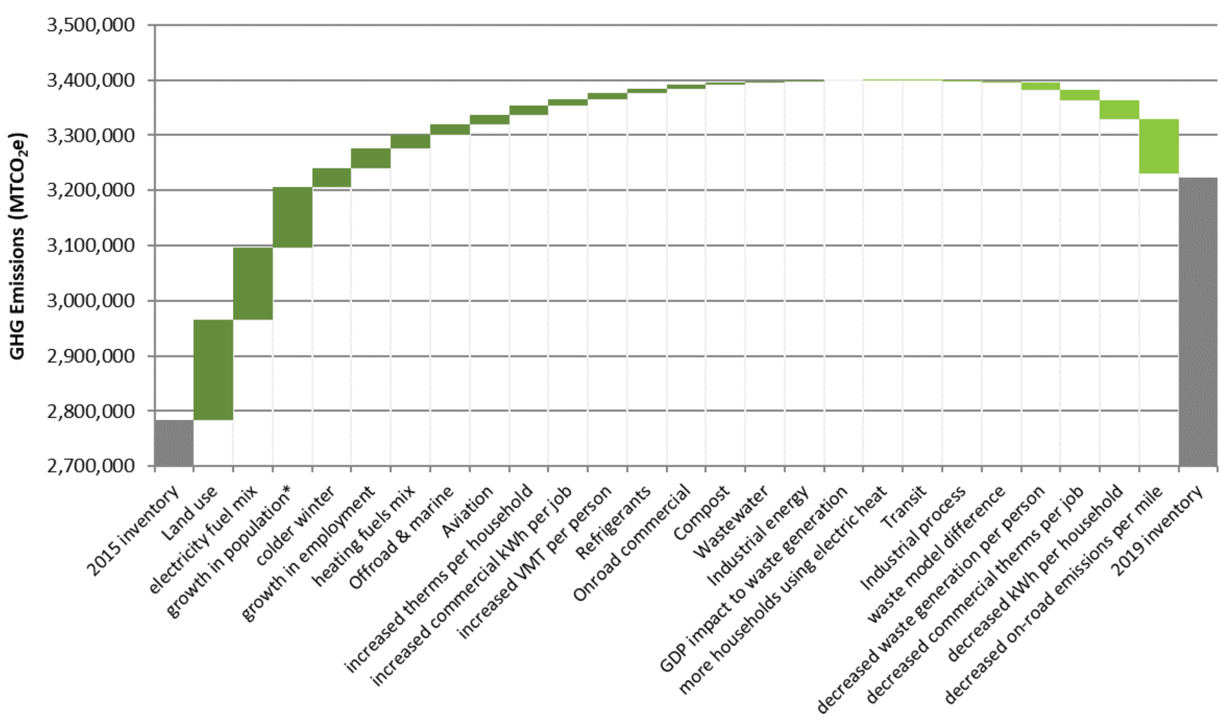


Figure 2525 shows a detailed breakdown of the factors contributing to increases and decreases, as listed below.

Figure 25. Detailed contributions to change between the 2015 and 2019 GHG inventories.



Increases

Land use (+181,000 $MTCO_2e$) is the total change in emissions from land use practices, including agriculture and tree loss.

Electricity fuel mix (+131,000 $MTCO_2e$) is the impact of shifting electricity generation sources.

Population (+110,000 $MTCO_2e$) includes the impacts of increased housing, increased driving, and increased solid waste generation driven by Kitsap County's growing population. Kitsap County's population increased 4.6% from 258,000 in 2015 to 270,100 in 2019.

Colder winter (+35,000 $MTCO_2e$) is the increased demand for heating fuels and electricity because of colder winter weather.

Employment (+34,000 $MTCO_2e$) increases with growth in business activity in Kitsap County and drives increased consumption of energy for heating, cooling, lighting, and other building energy. Kitsap County's employment increased 7% from ~47,245 in 2015 to ~50,536 jobs in 2019.

Heating fuels mix (+25,000 $MTCO_2e$) is a shift of residential and commercial uses to relatively more carbon-intensive forms of heating fuels.

Offroad and marine (+18,000 $MTCO_2e$) is the total change in emissions from these forms of transportation, which also includes change in commercial rail emissions. They are not subject to decomposition, so the bar shows the total change in their emissions, driven in part by population, economic growth, and additional, minor factors. Offroad equipment data comes from the EPA MOVES model which downscales national data and may not reflect local changes.

Increased natural gas use per household (+17,000 $MTCO_2e$) is the net remaining change after accounting for weather, and for the percent of households shifting from fuels to electricity for heating. This change is likely influenced by multiple positive and negative factors, including consumer behavior, changes in average home size, and changes to building and equipment efficiency.

Aviation (+17,000 $MTCO_2e$) is the impact of increased activity at SeaTac commercial airport. This sector is not subject to decomposition, so the bar shows the total change in emissions, driven in part by population and economic growth.

Increased commercial kWh/job (+12,000 $MTCO_2e$) is the net remaining change after accounting for weather. This change is likely influenced by multiple positive and negative factors, including occupant behavior and building equipment and controls.

Increased car trips per person (+11,000 $MTCO_2e$) represents the change in driver behavior leading to more gasoline use per person.

Refrigerants (+8,000 $MTCO_2e$) this increase was driven primarily by increased use of HFCs in refrigeration/air conditioning systems, fire suppressants, and foam manufacture. This data is based on national averages and Kitsap County's population and may not reflect local changes.

Onroad commercial vehicles (+7,000 $MTCO_2e$) is the total change in emissions from this source, which was not subject to further decomposition.

Compost (+3,000 $MTCO_2e$) is the total change in emissions from this source. Note that composting emissions were not calculated in 2015 due to data limitations.

Industrial energy use (+2,000 $MTCO_2e$) represents the emissions increase from combined industrial electricity, natural gas, and other fuel usage.

Wastewater treatment (+2,000 $MTCO_2e$) is the total change in emissions from this source.

Decreases

Improved vehicle efficiency (-99,000 $MTCO_2e$) is the reduction in emissions associated with reduced gasoline consumption in newer vehicles meeting more stringent federal standards.

Decreased electricity use (kWh) per household (-32,000 $MTCO_2e$) represents the changes in behavior and building stock resulting in reduced residential electricity usage. This is the net remaining change after accounting for weather and transition of building heating from fossil fuels to electricity.

Decreased commercial therms per job (-20,000 $MTCO_2e$) is the net remaining change after accounting for weather. This change is likely influenced by multiple positive and negative factors, including occupant behavior and building equipment and controls.

Decreased waste generation per person (-13,000 $MTCO_2e$) is the impact of less waste per person sent to landfill.

Waste model difference (-2,000 $MTCO_2e$) is the difference between the change in solid waste disposal emissions as modeled in the inventories, and the change as modeled within the contribution analysis tool.

Industrial process (-1,000 $MTCO_2e$) is the total change in emissions from industrial sources; it does not include industrial electricity or natural gas emissions.

Transit (-400 $MTCO_2e$) is the change in overall emissions from onroad transit vehicles.

More households using electric heat (-350 $MTCO_2e$) decreases emissions because of the efficiency of heat pumps and the relatively clean electricity supply in the region.

How Can We Meet Our Climate Goals?

Wedge Analysis Introduction

The wedge analysis forecasts emissions from 2019 through 2050 under the following scenarios:

1) **No action future:** forecasted emissions assuming no action is taken at the federal, state, or local level to reduce emissions.

2) **Federal, state, and regional policies**: forecasted emissions after accounting for impacts of current federal, state, and regional policy.

3) **Additional action:** additional reductions needed to meet the PSRC VISION 2050 emission reduction targets (50% below 1990 baseline levels by 2030 and 80% below 1990 baseline levels by 2050).

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

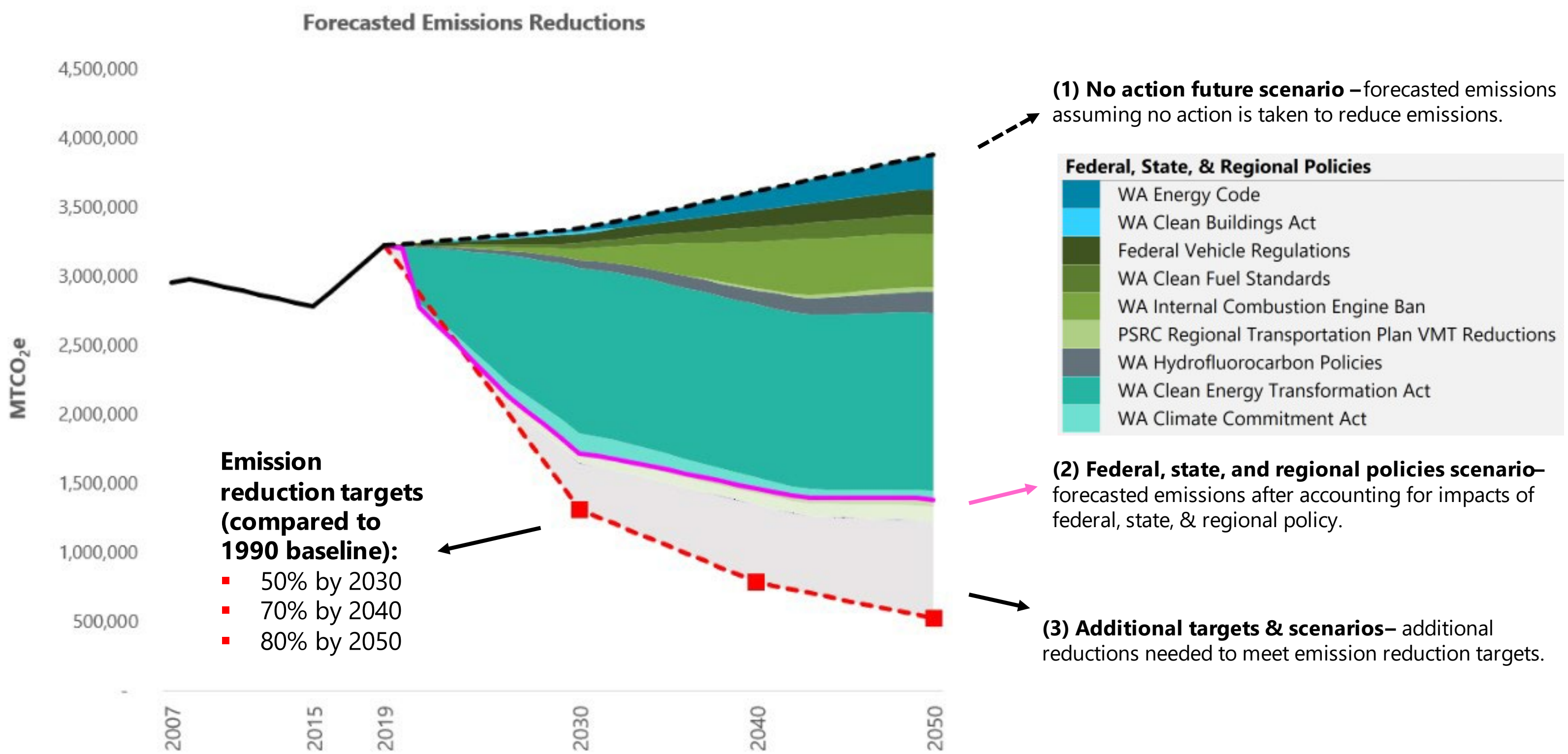
Results

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

- Under a **no-action future**, we estimate that Kitsap County GHG emissions will increase 48% by 2050.
- We estimate that **existing federal, state, and regional policies** will reduce Kitsap County's GHG emissions by 47% by 2050.
- **Additional targets/reductions** will be needed to acehive a 50% reduction by 2030, 70% reduction by 2040, and 80% reduction by 2050.[7]

[7] Kitsap County has not yet committed to reduction targets; targets presented here are hypothetical.

Figure 26. Forecasted emission reductions under three scenarios.



No-Action Future Scenario

The "no-action future" scenario modeled Kitsap County's geographic emissions assuming no 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. Scalers used to estimate GHG emissions under no-action future scenario.[8]

	% Change Compared to 2019		
	2030	**2040**	**2050**
Population	+2%	+10%	+19%
Jobs	+11%	+25%	+39%
Service Population	+4%	+14%	+24%

Federal, State, & Regional Policies Scenario

The "federal, state, & regional policies scenario" modeled Kitsap County's geographic emissions accounting for the impacts of current climate, energy, and transportation policies. The model sequentially models the emission reduction of each policy to eliminate the risk of "double counting" emission reductions. Therefore, the order by which policies were modeled influences their associated reductions. However, overall anticipated emissions reductions from identified policies is 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 Internal Combustion Engine Ban (SB 5974). The federal, state, & regional policies scenario resulted in a 33% 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

[8] Source: Puget Sound Regional Council

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, 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 20% reduction in the carbon intensity of transportation fuels 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 ICE ban, compared to baseline, we will model the following for EV use:

- 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 Internal Combustion Engine Ban (SB 5974)

Interpretation: Establishes a target that, "all publicly owned and privately owned passenger and light duty vehicles of model year 2030 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 sale of gasoline/diesel ICE passenger vehicles starting in 2030. For ICE ban, assuming a 15-year vehicle turnover rate, with the following proportion of new sales EV (a conservative estimate given that the ICE ban is currently a goal and lacks a clear accountability mechanism):

- 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 estimations 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 (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 must be made in overburdened communities to reduce health disparities and create environmental benefits, with an additional 10% allocated for tribal programs and projects.

Modeling Assumptions: State estimates that CCA will account for 26.2 million $MTCO_2e$ in statewide reductions by 2030. 2018 total emissions = 99.57 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 (however, this sector will receive directly-allocated no-cost allowances).
- Industrial processes (however, Emissions-Intensive Trade-Exposed facilities will received directly-allocated no-cost allowances).
- Transportation fuels (however, already covered to some extent by 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 increase in hydrogen or RNG in fuel mix) to 2030.
- Apply -15% emissions reduction estimate (consider applying a reduction factor) to industrial process emissions to 2030.
- Apply -23.5% fuel emissions factor reduction estimate (consider applying a reduction factor) to transportation emissions to 2030 and -30% to 2040 (includes reductions from CFS).

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 single occupancy, internal combustion engine vehicles; and transition buildings to clean, fossil-free energy sources. These additional emission reductions could be achieved through both local and regional action, including use of available funding streams such as from the state and federal government (e.g., Inflation Reduction Act and Infrastructure Investment and Jobs Act).

An Excel-based wedge analysis tool 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 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

In 2030, the largest sources of emissions under the modeled scenarios will be tree loss, on-road vehicles, and natural gas, representing about 32%, 19%, and 14% of 2030 emissions, respectively (Figure 27). By 2050, the largest sources of emissions will be tree loss (44%), natural gas (20%), and landfilled waste (8%) (Figure 28). More emissions reductions will be needed to meet the target emissions for future years.

Figure 27. Emissions in 2019, 2030, 2040, and 2050 compared to future targets.

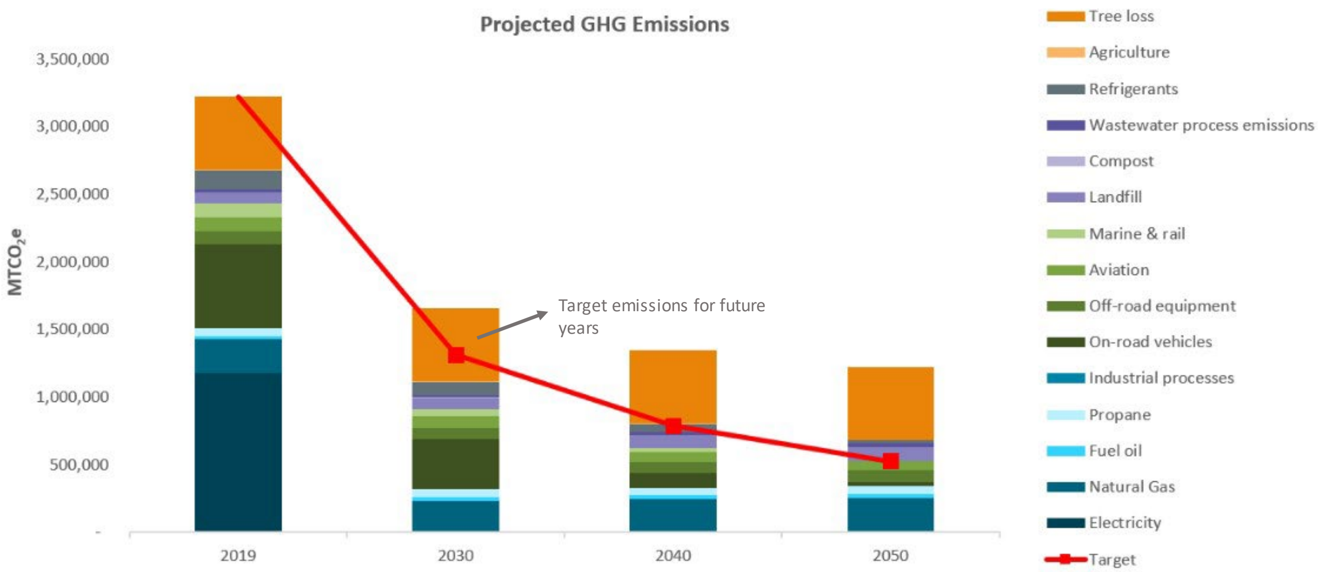
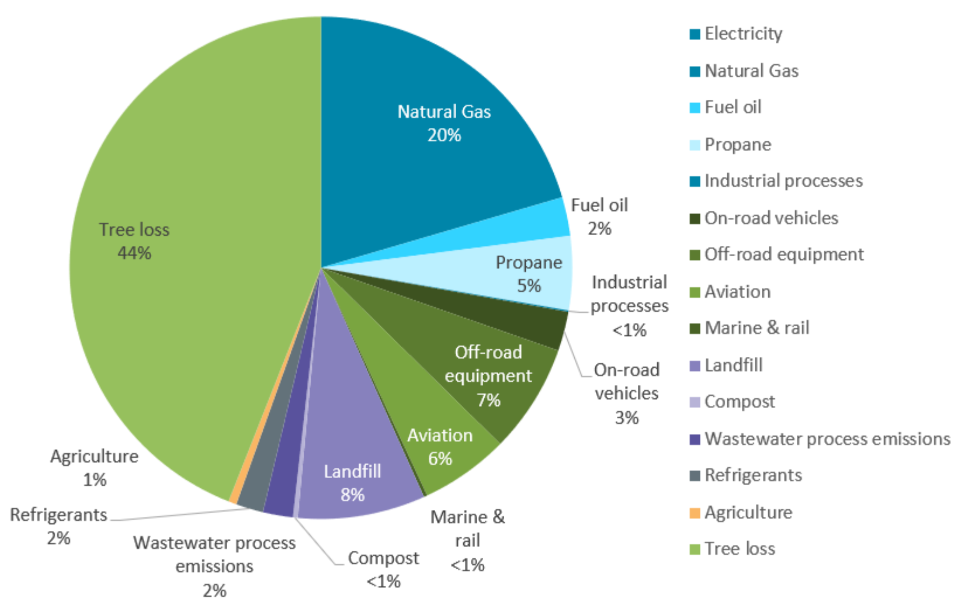


Figure 28. Remaining 2050 emissions under modeled emissions scenario.

Total = 1,222,517 MTCO$_2$e



When all feasible emissions reductions are achieved, carbon removals could be considered to achieve long-term net carbon neutrality goals. Currently, we estimate that County lands sequester approximately 942,000 MTCO$_2$e per year.

Appendix A. Inventory Methodology

Approach & Data Sources

Conducting the inventory involved identifying and applying activity data and emissions factors, summarized in Table 53 and detailed in the following sections:

- **Activity data** quantify levels of activity that generate GHG emissions, such as miles traveled and kWh of electricity consumed.
- **Emission factors** (EFs) 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 Data	Emissions Factors (EFs)
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 fuel consumption estimates by route	Ferry emission factors from Ports Emissions Inventory Guidance: Methodologies for Estimating Port-related and Goods Movement Mobile Source Emissions (USEPA, 2020) EPA emissions factors for ferry fuels (USEPA, 2021)
Building Energy		
Electricity	Electricity consumption (PSE)	Utility-specific emissions factors (Puget Sound Energy, 2021)
Natural Gas	Natural gas consumption (Cascade Natural Gas)	National emissions factor (USEPA, 2021)
Residential fuel oil	Washington state fuel sales (EIA, 2019)	EPA emissions factors for distillate fuel oil no.1 (USEPA, 2021)

Sector	Activity Data	Emissions Factors (EFs)
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	Tonnage and composition data from WA Department of Ecology (WA Dept. of Ecology, 2018) [9]	EPA WARM v15 model
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		
Substitution of ozone-depleting substances (ODS)	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	Tonnage and composition data from WA Department of Ecology (WA Dept. of Ecology, 2018) [10]	EPA WARM v15 model
Forest sequestration	$MTCO_2e$ sequestered by forest (Global Forest Watch, 2021)	

Built Environment

Electricity & Natural Gas

Emissions from electricity and natural gas were determined by the **kWh and therms consumed** within Kitsap County for the inventory years multiplied by the **utility- and year-specific emissions factors**.

Using Puget Sound Energy's annual reported CO_2, CH_4, N_2O, and SF_6 emissions and total kWh generated and purchased, gas-specific emissions factors were calculated for each inventory year and applied to the

[9] 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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total electricity consumption (Puget Sound Energy, 2021). Cascade Natural Gas does not have data on its emissions factor, so the EPA's national estimate was used for this inventory (USEPA, 2021).

Energy consumption data was procured directly from PSE and Cascade Natural Gas (CNG) for 2019 for residential, commercial, and industrial sectors, including transport customers within those sectors.

Emissions from electricity and natural gas transmission and distribution (T&D) were also accounted for in these inventories. Emissions from electricity loss were calculated by multiplying the energy consumed by the grid loss factor from eGRID (USEPA, 2021), which follows the U.S. Community Protocol outlined by ICLEI (ICLEI, 2013). Emissions from natural gas leakage were calculated using the emissions factor provided by ClearPath, ICLEI's greenhouse gas inventory software platform (ICLEI, 2021).

Other Sources

Fuel Oil & Propane

Residential heating fuel and propane emissions were calculated using EIA state and national residential propane and heating oil sales data. Kitsap County's portion of total fuel sales were determined using ACS home heating fuel data.

Commercial and industrial fuel oil emissions were calculated using EIA industrial and commercial fuel oil sales data downscaled by the portion of industrial and commercial employees in Kitsap County. Employment data was collected from the Employment Security Department of Washington State, which provides the data on the number of employees across industries. Commercial and industrial propane sales data was not available and was thus omitted from the inventory.

Propane and fuel oil emissions were both calculated using EPA emissions factors (USEPA, 2021).

Industrial Process

Industrial process emissions were collected from the EPA Facility Level Information on Greenhouse gases Tool (FLIGHT), which collects GHG emissions reported by large facilities in Kitsap County. FLIGHT data on industrial emissions from the combustion of natural gas were removed to avoid double counting with industrial natural gas emissions calculated from utility-reported energy data.

Transportation

On-Road Transportation

On-road passenger vehicle and freight emissions were calculated by the Puget Sound Regional Council (PSRC). PSRC applied its activity-based travel model data to the EPA's Motor Vehicle Emission Simulator (MOVES) model to arrive at emissions estimations by vehicle type.

PSRC's activity-based travel model produces vehicle miles traveled (VMT), facility type, and speed estimates for time periods within a typical workday in Kitsap County. VMT outputs were provided by vehicle type for passenger vehicles, medium trucks, and heavy trucks. At the time of this inventory, PSRC had developed and calibrated this model for analysis years 2006, 2010, 2014, and 2018.

MOVES estimates from cars, trucks, and non-highway mobile sources under user-defined vehicle types, time periods, geographic areas, vehicle operating characteristics, and road types. The model simulates emissions for various vehicle operating processes, such as running, starts, or hoteling. PSRC's use of the model was run using California LEV II standards, which were adopted by the State of Washington beginning with 2009 model year vehicles. PSRC also used County-specific input files provided by the Washington Department of Ecology that reflect the climate, vehicle mix, and inspection and maintenance requirements specific to each county.

Because the PSRC model was only run for 2006, 2010, 2014, and 2018 PSRC linearly interpolated results from modeled years to estimate emissions in past inventories and for this inventory. Both activity data in VMT and the running, start, and hoteling emissions were scaled linearly in this way.

Transit emissions were calculated by multiplying fuel use for Kitsap Transit by standard fuel-specific emissions factors from the USEPA.

Aviation

Aviation emissions were based on annual jet fuel and aviation gas usage at SeaTac (data from Kitsap County's Bremerton National Airport was not provided). Kitsap County's portion of SeaTac jet fuel usage was determined using SeaTac passenger survey data indicating the portion of passengers whose origin or destination was within Washington state as well as King County specifically. The remaining SeaTac fuel usage was distributed to Kitsap and the other Washington counties that the airport primarily serves based on income weighted population.

Emissions were calculated using EPA emissions factors (USEPA, 2021).

Other Sources

Maritime & Rail

To estimate emissions from **ocean-going vessels and freight rail**, we scaled the 2016 Puget Sound Maritime Air Emissions Inventory (Starcrest Consulting, 2018) emissions estimations by 2019 cargo tonnage and vessel calls. Kitsap County's portion of ocean-going vessel maneuvering and hoteling emissions are from vessels visiting the ports within the county. Ocean-going vessel transit emissions are from vessels transiting through to either visit the ports within Kitsap County or elsewhere.

Data from Washington State Ferries route statements and annual reports on fuel cost by route and total fuel consumption were used to estimate **ferry** emissions.

Non-Road Vehicles and Equipment

Emissions from **non-road vehicles and equipment** were calculated using EPA MOVES3, a model that estimates emissions from mobile sources (USEPA, 2020). The non-road sectors from the MOVES3 model included in this inventory are recreational, construction, industrial, lawn/garden, agriculture, commercial, logging, airport support, oil field, pleasure craft, and railroad. The model produces CH_4 and CO_2 emissions per sector for gasoline, LPG, CNG, and diesel.

Solid Waste & Wastewater

Solid Waste

Emissions from **generation and disposal of solid waste** were estimated by multiplying the tons generated by material type-specific emissions factors derived from the EPA WARM v15 model (USEPA, 2020). We obtained waste and compost composition data from the 2015-16 Washington Statewide Waste Characterization Study (WA Dept. of Ecology, 2018). We translated these waste composition data into the EPA WARM categories and applied landfill gas capture estimations to estimate methane emissions (we assumed the U.S. average landfill gas capture rate).

Wastewater

Kitsap County's emissions from **wastewater** come from treatment processes and combustion of waste gas, which produces both methane and nitrous oxide. Emissions were calculated for all five of Kitsap County's wastewater treatment plants—Bremerton, Central Kitsap, Manchester, Suquamish, and Kingston—as well as the estimated 54,000 septic systems around the county. Emissions were estimated based on the type of treatment processes at a given plant—such as the use of aerobic digestion—as well as the size of the population served. Emissions were calculated using equations and emissions factors provided by the U.S. Community Protocol (ICLEI, 2013).

Refrigerants

To estimate emissions from the **substitution of ozone-depleting substances**, national emissions reported by the EPA were scaled by population for Kitsap County (USEPA, 2021). SF_6 emissions from electricity utilities were included in the electricity emissions section, as we assume that these emissions are integrated into overall $MTCO_2e$/kWh emissions factors reported by the utilities.

Land Use

Agriculture

Agricultural emissions were calculated following the methodology from the U.S. Community Protocol, developed by ICLEI. Agricultural emissions stem **from livestock enteric fermentation, manure management, and soil**.

For these calculations, the EPA Inventory Annexes provided values for the following: livestock enteric fermentation emissions factors, distribution of waste management systems, typical animal mass, daily and annual volatile solid production rates, maximum CH_4 producing capacity per pound of manure, methane conversion factors based on manure management system, daily excreted nitrogen rates, nitrous oxide emissions factors, nitrogen lost through volatilization, and nitrogen lost through runoff and leaching. The U.S. Community Protocol Appendix G provided values for volatilization and runoff/leaching emissions factors. Data on the number of animals in Kitsap County was sourced from the USDA 2017 Census of Agriculture. The EPA Inventory and Inventory Annexes provided nationwide values for direct and indirect N_2O emissions from soils, and the total U.S. cropland acreage was provided by the 2017 USDA Census of Agriculture. This national data was used to create an emissions factor for soil, which was applied to the acres of cropland in Kitsap County.

The USDA publishes the Census of Agriculture every five years, so the animal number values are not directly aligned with inventory years. For this inventory, the 2012 numbers were used for the 2015 inventory, and the 2017 numbers were used for 2019. The 2022 Census of Agriculture currently underway.

Tree Loss

Emissions from tree cover loss were estimated by the **Global Forest Watch**, which was established by the World Resources Institute. Global Forest Watch's online tool estimates **annual tree cover loss** at the county level. Tree cover loss does not necessarily indicate deforestation, as it can result from harvesting, fire, disease, or storm damage (Global Forest Watch, 2021).

This data set defines tree cover as all vegetation that is taller than five meters, and the data resolution is 30 by 30 meters. Emissions estimates include CO_2, NH_4, and N_2O and relevant carbon pools, such as aboveground and belowground biomass, dead wood, and soil. Global Forest Watch uses calculation methods that follow IPCC greenhouse gas inventory guidelines (Harris, et al., 2021).

Carbon Sequestration

Solid Waste

U.S. EPA WARM v15 model defines carbon sequestration as removal of carbon (usually in the form of carbon dioxide) from the atmosphere, by plants (through forest carbon sequestration) or by technological means (landfill carbon sequestration).

Tree Sequestration

Carbon sequestration by tree cover was estimated by the **Global Forest Watch**. The online tool estimates metric tons of CO_2e sequestered at the county level. Sequestration estimates are based on **forest type, ecozone, forest age, and number of years of sequestration**. Carbon removals were averaged over a twenty-year period because sequestration data was not available as a time series; therefore, sequestration values are the same across years.

Approach & Data Limitations

Notable limitations of our approach and data sources are summarized below:

- **Land use change emissions and sequestration:** Global Forest Watch provides county-level annual emissions from tree cover loss and an average annual sequestration value. The tool does not provide year-specific sequestration rates or values; the annual sequestration value is an average of sequestration in Kitsap County over the time period 2001–2020. Global Forest Watch also does not have data on annual forest cover gain or total forest cover acreage by year (Global Forest Watch, 2021).
- **Propane and fuel oil:** EIA industrial and commercial propane sales data was not available so these emissions were not calculated for this inventory. EIA residential propane data was only avaiable at the regional level, so the analysis required downscaling total sales from the entire western region (Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington).
- **Agriculture:** The Census of Agriculture is published by the USDA every five years, so the 2017 numbers of animals and acres of cropland are used for the 2019 inventory (USDA, 2019).
- **Aviation:** Aviation emissions are attributed based on passenger data from SeaTac. At the time of this inventory, King County was the only county for which quantiative survey data was available. Therefore, attribution of SeaTac fuel consumption to Kitsap, Pierce, and Snohomish counties is an estimate based on a qualitative summary of survey data. Additionally, fuel data from Kitsap County's regional aiport—Bremerton National Airport—were not provided and therefore are not included in this inventory.
- **Wastewater:** Data from several treatment plants was unavailable; emissions from these plants were based on publicly available information on population and treatment processes.
- **Refrigerants:** Emissions from refrigerants are scaled by national data, so they do not take into account local factors (e.g., milder summers that result in less air conditioning).Furthermore, not all inventory values are based on locally derived data. Table 64 summarizes some of the limitations and sensitivities of data used in the inventory.

Table 6. Summary of data sensitivity to local conditions for the 2019 geographic inventory.

Sector	Percent of total 2019 emissions	Values are sensitive to local conditions	Values are sensitive to local conditions, with some exceptions	Values are based on scaled regional/state data	Values are based on scaled national data
Transportation	**28%**				
On-road vehicles	19%		✓		
Aviation	3%			✓	
Non-road vehicles and equipment	3%			✓	
Freight and passenger rail	0%		✓		
Marine vessels	3%		✓		
Building Energy	**47%**				
Electricity	36%	✓			
Natural Gas	8%	✓			
Fuel oil	1%			✓	
Residential propane	2%			✓	
Industrial processes	<1%		✓		
Solid Waste & Wastewater	**3%**				
Solid waste generation & disposal	3%		✓		
Wastewater process emissions	<1%		✓		
Refrigerants	**4%**				
Substitution of ozone-depleting substances (ODS)	4%				✓
Land Use	**17%**				
Agriculture	<1%		✓		
Tree cover loss	17%	✓			
Sequestration	**N/A**				
Solid waste disposal	N/A		✓		
Forest sequestration	N/A	✓			

Methodology Updates

Several methodological differences between the current inventory and previous inventories led to changes in GHG emissions reported (see Table 6). The 2015 and 2019 values reflected in this inventory report have been calculated using the current methodology.

Table 6. Brief methodological outline of previous inventories and the 2019 inventory.

Sector	Methodology for Previous Inventories	Methodology for 2019 Inventory Update
Transportation		
On-road vehicles	PSRC activity-based travel model applied to MOVES model	Same, with additional attribution by vehicle fuel type
Aviation	SeaTac jet fuel and aviation fuel usage downscaled through a standard LTO estimate	SeaTac and Boeing Field jet fuel and aviation fuel usage downscaled to jurisdiction through passenger survey and income weighted population
Non-road vehicles and equipment	MOVES2014 model	MOVES3 model (newest version)
Freight and passenger rail	PSEI inventory	PSEI inventory, scaled to years/jurisdictions by tonnage
Marine vessels	PSEI inventory used for OGV, Ferry fuel consumed and latest harbor craft emission factors from EPA guidance.	PSEI inventory, scaled to years/jurisdictions by tonnage and vessel calls. Ferry fuel consumed by route.
Building Energy		
Electricity	kWh consumed and emissions factors based on WA Fuel Mix Disclosure reports	kWh consumed and utility-specific emissions factors calculated or pulled from utility emissions reports
Natural Gas	Therms consumed and EPA natural gas emissions factor	No change
Residential fuel oil	EIA sales data downscaled using ACS house heating data	Methodology remained the same; used ACS 5-year estimates, which are more comprehensive than the previously used 1-year estimates
Residential propane	EIA sales data downscaled using ACS house heating data	Methodology remained the same; used ACS 5-year estimates, which are more comprehensive than the previously used 1-year estimates
Industrial processes	Calculated emissions from individual Kitsap County facilities monitored by PSCAA	All facility emissions collected by the EPA FLIGHT tool
Solid Waste & Wastewater		
Solid waste generation & disposal	Applied "custom" modified version of EPA WARM v14 emissions factors to tonnage estimates	Applied more "standard" emission factors from EPA WARM v15 emissions factors to tonnage estimates

Sector	Methodology for Previous Inventories	Methodology for 2019 Inventory Update
Wastewater process emissions	Included biogas emissions, BOD_5 emissions, and septic systems	Included the same emissions as 2015, plus emissions from Central Kitsap's combustion of digester gas
Refrigerants		
Substitution of ozone-depleting substances (ODS)	National EPA value scaled to region by population	No change
Switchgear insulation (SF_6)	SF_6 emissions from PSE	PSE SF_6 emissions reflected in PSE emissions factor and not included in refrigerants
Land Use		
Agriculture	Enteric fermentation and manure management from U.S. Community Protocol	Calculations updated to more closely align with the U.S. Community Protocol
Tree cover loss	Permit data and carbon storage assumptions	Global Forest Watch estimates
Sequestration		
Solid waste disposal	Apply tons to WARM v14 emissions factors	No change (applied to WARM v15, but EFs have not changed)
Forest sequestration	Not included	Global Forest Watch estimates

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