SALEM,OREGON

CLIMATE ACTION PLAN
CITY OF SALEM

CITY OF Salem AT YOUR SERVICE

2021 Inventory of Community Greenhouse Gas Emissions

Prepared For:

Salem, Oregon

Produced By:

ICLEI – Local Governments for Sustainability USA
February 23, 2023

Table of Contents

Tables and Figures

List of Tables

List of Figures

Credits and Acknowledgments

City of Salem

Jue Zhao, Wastewater Treatment Division Manager, Public Works Department

Stephen Celest, Operations Manager, Public Works Department

Alicia Blalock, Administrative Division Director, Public Works Department

Dwayne Barnes, Utility Operations Manager, Public Works Department

John Paskell, Airport Manager, Public Works Department

Patricia Farrell, Climate Action Plan Advisor, Public Works Department

Keith Bondaug-Winn, Management Analyst II, Public Works Department

Heather Dimke, Management Analyst II, Public Works Department

Robert Chandler, Assistant Public Works Director

Marion County

Brian May, Environmental Services Division Manager

Public Transit & Utilities

Ted Stonecliffe, Cherriots (Salem Area Mass Transit District)

Chase Kitchen, Amtrak

Jacob Knudsen, Salem Electric

Wendy Veliz, Portland General Electric

Matt McHill, Portland General Electric

Sebastian Weber, Northwest Natural

Ryan Bracken, Northwest Natural

Other

Jamie Pedersen, Mid-Valley Garbage & Recycling Association

Melissa Schop, Union Pacific Railroad

ICLEI – Local Governments for Sustainability USA

Executive Summary

The City of Salem made a commitment in October of 2020 to reduce greenhouse gas (GHG) emissions and to prepare for the effects of climate change when City Council adopted two goals: (1) to reduce GHG emissions 50 percent by 2035 from the baseline year of 2016; and (2) to be a carbon neutral city by 2050. The 2022 Salem Climate Action Plan includes nearly 200 actions and strategies Salem can take to meet these GHG goals and to increase community resilience to climate changes. Conducting an inventory of GHG emissions can provide useful information for prioritizing among possible actions designed to reduce GHG sources. Conducting a series of GHG inventories can help identify trends and further aid local governments in determining how to allocate resources.

The City's initial GHG emissions inventory was completed in 2019. This sector-based inventory for the Salem community used data from 2016 and was prepared using the "Global Protocol for Community-Scale Greenhouse Gas Emission Inventories" (GPC). The GPC is an internationally accepted method for calculating emissions at a community-wide scale. This method calculates the GHG emissions based only on activities occurring within Salem's city limits, such as transportation, energy use, and production of waste. The GPC method does not estimate emissions that are generated when goods and services are purchased within city limits.

This report provides the results of Salem's second sector-based community-wide GHG inventory. It only represents emissions from within Salem's city limits and the GHG inventory data collected in 2021. This updated inventory was calculated using the GPC methodology, the ICLEI's ClearPath Climate Planner tool, and used data provided by the City of Salem, Marion County, local utilities, garbage haulers, and public transit providers.

Thank you to all the individuals who contributed time and data to this effort. An updated inventory would not have been possible without your time and support.

Key Findings

Based on the 2021 data and methodology used to determine emissions, it is estimated that 1,233,620 Metric Tons of CO_2 equivalent (MT CO_2e) were released in Salem in 2021. This amount can be equated to approximately 6.94 MT CO_2e per capita. At first glance, these results represent an overall decrease of 20%, or 302,060 MT CO_2e from the values determined in 2016. However, owing to differences in methodologies and errors identified in the 2016 estimates, the actual reduction is estimated to be much less than 20%. Details on the data and calculation methods are provided later in this report with supporting details included in the Appendix.

Emissions Breakdown

Figure 1 provides a breakdown of the 2021 community-wide emissions by activity or sector. This shows that the largest source of emissions in Salem is from Transportation & Mobile Sources (41%). The next largest sources are Commercial & Industrial Energy use (32%), followed by Residential Energy use (23%). These latter two sectors account for the use of electricity as well as the use of natural gas and other fuels in buildings and industrial processes. When combined, the Solid Waste and Water & Wastewater sectors were responsible for approximately 4% of Salem's total emissions.

The Inventory Results section of this report provides a general profile of the emissions sources within the city limits of Salem. This profile is key to guiding local reduction efforts.

EMISSIONS AT A GLANCE

1 **Transportation**
41%

2 **Commercial & Industrial Energy**
32%

3 **Residential Energy**
23%

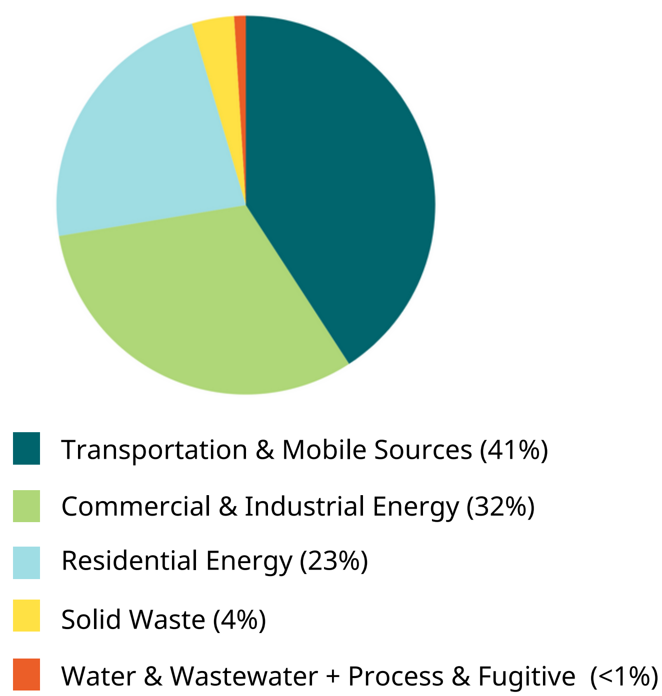

Figure 1: Community-Wide Emissions by Sector

Inventory Methodology

Understanding a Greenhouse Gas Emissions Inventory

As more local governments commit to GHG reduction goals, the need for a standardized approach to quantify GHG emissions has proven essential. The inventory in this report used the approach and methods provided by the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC), which is described below.

Global Community Protocol

Version 1.1 of the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC 1.1) was published in 2014 and revised in 2019. The GPC represents a national standard in guidance to help US local governments develop community GHG emissions inventories [1]. It establishes reporting requirements for all community GHG emissions inventories, provides detailed accounting guidance for quantifying GHG emissions associated with a range of emission sources and community activities, and provides a number of reporting frameworks to help local governments customize their community GHG emissions inventory reports based on their local goals and capacities. In 2022, the World Resources Institute (WRI), C40 Cities and ICLEI released The Supplemental Guidance for Forests and Trees to consistently identify, calculate, and report on GHG emissions and removals by forests and trees within a community's boundaries. The WRI guidance is aligned with the 2019 Refinement to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and Appendix J of the US Community Protocol (USCP).

Sector-Based Inventory

The community inventory in this report includes emissions from the five sectors required by the GPC as well as emissions and sequestration from forests and trees (Appendix J of the USCP). The six sectors included in this inventory are as follows:

- Use of electricity by the community
- Use of fuel in residential, commercial and industrial stationary combustion equipment
- On-road passenger and freight motor vehicle travel
- Use of energy in potable water and wastewater treatment and distribution
- Generation of solid waste by the community
- Net carbon flux from agriculture, forests and trees outside of forests, changes in land use (AFOLU)

[1] Greenhouse Gas Protocol. GHG Protocol for Cities. Retrieved from https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

Three GHGs are included in this inventory: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Many of the charts in this report use emissions calibrated to “carbon dioxide equivalent” (CO_2e) values. CO_2e is calculated using the Global Warming Potentials (GWP) for methane and nitrous oxide from the IPCC 5th Assessment Report, as shown in Table 1 [2].

Greenhouse Gas	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265

Table 1: Global Warming Potential Values (IPCC, 2014)

Quantifying Greenhouse Gas Emissions

Sources and Activities

Every member of a community contributes to GHG emissions in many ways. Two central categorizations of emissions are used in the community inventory: 1) GHG emissions that are produced by “sources” located within the community boundary, and 2) GHG emissions produced as a consequence of community “activities.” These two terms are defined in Table 2 below.

Source	Activity
Any physical process inside the jurisdictional boundary that releases GHG emissions into the atmosphere.	The use of energy, materials, and/or services by people within the community boundaries that result in the creation of GHG emissions.

Table 2: Source vs. Activity for Greenhouse Gas Emissions (GHG)

[2] AR5 Synthesis Report: Climate Change 2014. IPCC. Retrieved from https://www.ipcc.ch/report/ar5/syr

Base Year

The inventory process requires the selection of a base year with which to compare current emissions. Salem’s GHG emissions inventory utilizes 2016 as its baseline year because this represents Salem's first completed community-wide inventory.

Quantification Methods

GHG emissions can be quantified in two ways:

- Measurement-based methodologies, which uses the direct measurements of GHG emissions from a monitoring system from, for example, a power plant, a wastewater treatment plant, a landfill, or an industrial facility.
- Calculation-based methodologies, which estimate emissions using activity data and emission factors. To calculate emissions, the basic equation below is used:

Activity Data x Emission Factor = Emissions

Most emissions sources in this inventory are quantified using calculation-based methodologies. Activity data refer to the relevant measurement of energy use or other GHG-generating processes such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. Please see the appendices for a detailed listing of the activity data used in developing this inventory.

Known emission factors are used to convert energy usage or other activity data into associated quantities of emissions. Emissions factors are usually expressed in terms of emissions per unit of activity data, such as pounds of CO2/kWh of electricity. For this inventory, calculations were made using ICLEI’s ClearPath Climate Planner tool.

Community Emissions Inventory Results

The total community-wide emissions for the 2021 inventory are shown in Table 3 and Figure 2.

Table 3: 2021 Community-Wide Emissions Inventory

Sector	Fuel or Source	2021 Usage	Usage Unit	2021 Emissions (MTCO2e)
Residential Energy	Electricity	650,884,350	kWh	167,377
	Natural Gas	21,447,944	Therms	114,074
	Propane	34,596	MMBtu	2,147
	Distillate Fuel Oil No. 2	5,031	MMBtu	375
	Kerosene	774	MMBtu	59
	Wood	90,439	MMBtu	901
Residential Energy Total				**284,933**
Commercial Energy	Electricity	585,637,408	kWh	160,103
	Natural Gas	23,442,296	Therms	124,681
Commercial Energy Total				**284,784**
Industrial Energy	Electricity	138,943,827	kWh	39,519
	Natural Gas	3,969,705	Therms	21,069
	Mixed Industry From DEQ			45,454
Industrial Energy Total				**106,042**
Transportation & Mobile Sources	Gasoline	873,300,459	VMT	364,674
	Diesel	90,445,962	VMT	133,260
	Public Transit & Rail			3,229
	Aviation			4,404
Transportation & Mobile Sources Total				**505,567**

Table 3: 2021 Community-Wide Emissions Inventory (continued)

Sector	Fuel or Source	2021 Usage	Usage Unit	2021 Emissions (MTCO2e)
Solid Waste	Waste Sent to Landfill	73,047	Tons	21,205
	Waste Sent to Incinerator	61,148	Short Tons	21,195
	Composting			1,479
	Combustion of LFG			728
	Solid Waste Total			**44,607**
Water & Wastewater	Fugitive Emissions			5,296
	Water & Wastewater			**5,296**
Process & Fugitive	Natural Gas Pipeline Emissions			2,391
	Process & Fugitive Emissions Total			**2,391**
AFOLU	*Forest & Trees*			*-3,702*
	Total Emissions			**1,233,620**
	Total Emissions with Sequestration			**1,230,544**

*Blank cells are a result of variability in the format of available data by sector and fuel or source type.

Table 4: 2016 and 2021 Primary Community-Wide Emissions Comparison

Sector	Fuel or Source	2016 Usage	2021 Usage	2016 Emissions	2021 Emissions	Percent Change
Residential Energy	Electricity		650,884,350	171,525	167,377	-2%
	Natural Gas		21,447,944	96,815	114,074	18%
	Other Fuels			2,712	3,482	28%
	Residential Energy Total			**271,052**	**284,933**	**5%**
Commercial/ Industrial Energy	Electricity		585,637,408	226,496	199,622	-12%
	Natural Gas		23,442,296	108,434	145,750	34%
	Other Fuels			46,057	45,454	-1%
	Commercial/Industrial Energy Total			**380,987**	**390,826**	**3%**
Transportation & Mobile Sources				837,185	505,567	-40%
Solid Waste***				40,682	44,607	10%
Water & Wastewater****				5,774	5,296	-8%
Process and Fugitive				Not included	2,391	N/A
Total Gross Emissions Comparison**				**1,535,680**	**1,233,620**	**-20%**
Total Gross Emissions Comparison without Transportation and Mobile Sources**				**698,495**	**725,662**	**4%**

*Blank cells are a result of variability in the format of available data by sector and fuel or source type.
**Agriculture, Forestry, and Other Land Use category omitted from emissions total.
***2016 and 2021 data collection methods weren't comparable. 2016 was re-calculated using population difference (an increase of 9.65%) between the two years.
****Took out 2016 wastewater lagoon emissions due to error.

Comparison Discussion

Table 4 compares 2016 and 2021 emissions as MT CO2e. It should be noted that the process for calculating GHG emissions has continued to evolve. This complicates comparing the two emission estimates. In addition to continued improvements to data collection and calculation methodologies, new sources of data have become available. The primary differences between the two emission inventories are discussed below.

As shown in Table 4, the transportation sector shows a significant decrease (40%) in emissions since 2016. While it is possible that there has been a decrease in emissions from this sector since 2016, it is unlikely that the decrease is as high as 40%. Rather, a significant portion of this decrease is likely best explained by the fact that the 2021 inventory used a different source of data to estimate on-road vehicle miles traveled (VMT) than the 2016 estimate. The 2021 data used in this report were based on Google Environmental Insights Explorer (EIE), which first became available in 2018. These values were collected using Google's proprietary location history data. In contrast, the source for local VMT data in 2016 was the Salem-Keizer Metropolitan Area Travel Demand Model. This model provides a computer-generated estimation of vehicle trips and does not use on-the-ground measured data. It is recommended that no inferences be made regarding VMT-derived values or trends until the next GHG inventory is made, which is anticipated to be completed in the next 2-5 years and which will again use Google EIE.

After reviewing the activity data used in 2016 for solid waste, it was determined that this data set included errors that could not be traced or corrected. Because of the errors, the results of GHG estimates based on the 2016 data set were initially considered incomparable to the 2021 values. To make the 2021 estimates more comparable, the 2016 emission estimates were recalculated to show a 9.65% increase (matching the population increase) between the two years.

GHG emissions in the Commercial/Industrial Energy sector decreased by 12% for electric sources and increased by 34% for natural gas sources. A detailed breakdown of potential factors and interrelationships contributing to these changes is beyond the scope of this report. However, what is known is that between the GHG inventories of 2016 and 2021, the amount of power generated by solar and wind sources increased and the last coal-fired generating plant in Oregon was shut down.

In 2016, Salem estimated that 66,736 MT CO2e were emitted from the Water & Wastewater sector. A substantial portion of this total (60,962 MT CO2e or 91%) was based on estimated emissions from wastewater lagoons. A wastewater lagoon is where wastewater is collected in deep ponds and allowed to decompose with no other form of treatment. However, the City of Salem does not utilize a lagoon system, so this value from 2016 was included in the inventory in error. Table 4 shows the corrected 2016 emissions after removing the lagoon emissions. Using this corrected value, the emissions from the Water & Wastewater sector went down by 8% between 2016 and 2021.

Overall, simply using the combined values provided in Table 4 would show total GHG emissions in Salem decreased by 20% between 2016 and 2021. However, as discussed above, the estimated GHG emission level from the Transportation & Mobile Source sector for 2016 is unreliable, which means the calculated 40% reduction in this sector over the past five years is not a tenable indicator. By removing GHG emission estimates for the Transportation and Mobile Sources sector for both 2016 and 2021 while retaining all the other sectors for which 2016 values were determined, this results in an overall increase in emissions between 2016 and 2021 of 4%. This is shown in the final row of Table 4.

Figure 2 provides a visual comparison of the 2016 and 2021 emissions data using the pie chart breakdown provided in the 2016 inventory. This breakdown shows that transportation has continued to be the largest source of total emissions no matter how it is calculated, followed by electricity use and stationary combustion.

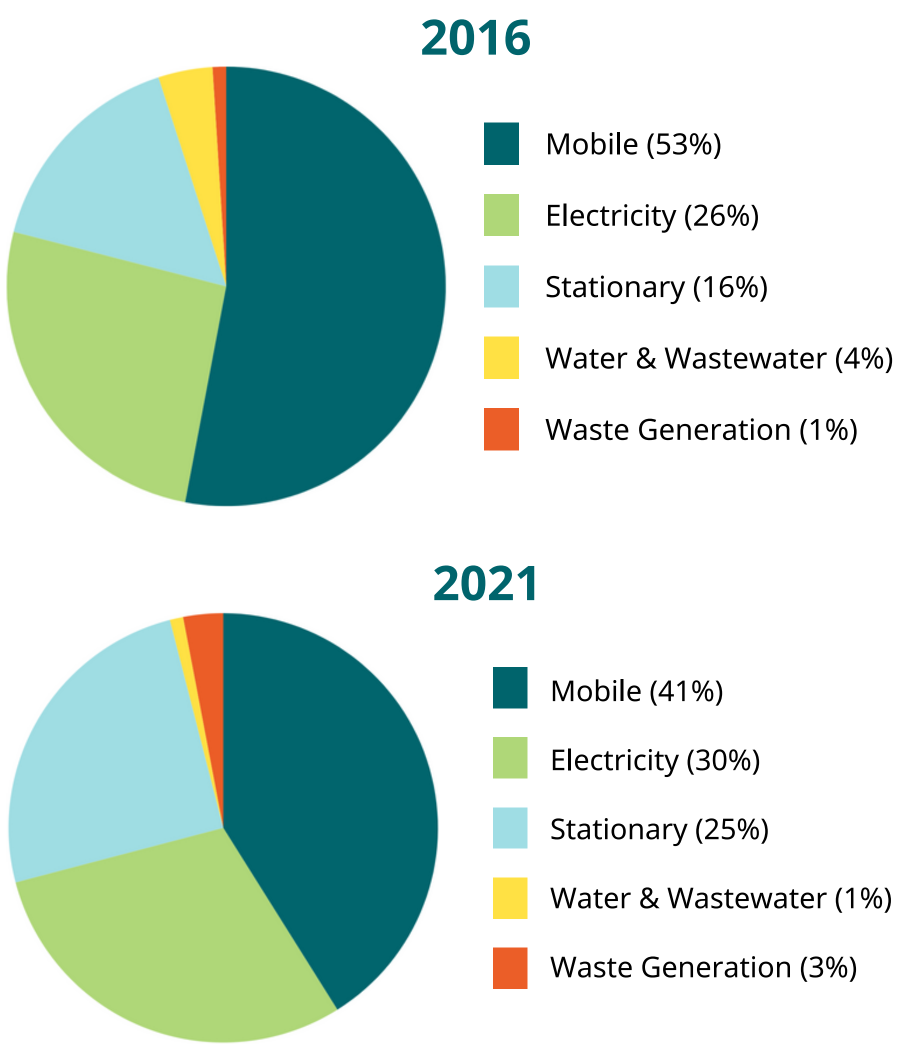

Figure 2: Comparison of 2016 and 2021 GHG Inventories, based on sectors used in 2016.

Tree Canopy Analysis

The manner in which GHG inventories are estimated for different types of land use is more complicated than for other sectors. In addition to both emitting and removing GHGs, there are multiple carbon pools that respond differently to management activities and natural disturbances, interannual variability is high, and measurements may not be as precise as it is in other sectors (See the USCP, Appendix J). At the time of publication for Salem's 2016 GHG Inventory, existing guidance for incorporating forest and tree carbon in community GHG inventories only considered removals of carbon from a community's forests and trees. Beginning in 2019, a number of updates to protocols and guidance to estimating carbon from the Agriculture, Forestry, and Other Land Use (AFOLU) sector required that communities include the "net flux" of carbon emissions and removals - carbon emitted to the atmosphere from the land and carbon removed from the atmosphere to the land.

In addition to this improved methodology, more accurate emissions and removals factor sets were developed to align with different forest and urban tree canopy typologies in the US. Using Salem's most recent high-resolution tree canopy data and the current National Land Cover Dataset (NLCD) for forests, emissions and removals were estimated for the area within Salem's jurisdictional boundary. In early 2023, the high-resolution tree canopy data were entered into a model developed by World Resources Institute (WRI) to apply the same analysis of NLCD to the high-resolution tree canopy data. When comparing the removals of carbon using the new methods to the previous estimate of removals from Salem's 2016 GHG Inventory, the estimate of removals is very similar - with differences likely arising from the improved removal factors and different alignment of forests and trees outside of forests. When applying the emissions of those land types to the estimate, a net annual average removal of 3,702 metric tons of CO2e can be incorporated into Salem's GHG Inventory.

Key Takeaways and Recommendations

Key Takeaways

As Salem's population increases and if no further actions are taken, GHG emissions may begin to decrease by 2035. This is attributed to changes in automotive fuel efficiency and utility decarbonization plans. Additional action will be needed to meet GHG emissions reduction goals. Based on the latest estimates provided in this report:

- Mobile combustion from on-road transportation continues to be the dominant source (41%) of emissions in Salem.
- Residential, commercial, and industrial energy use presently account for more than half (55%) of Salem’s total GHG emissions.
- Of the total gross emissions:
  - 30% of emissions are attributed to electricity generation/use
  - 25% of emissions are from stationary fuels (such as natural gas and propane)
- Local activities that increase energy efficiency, reduce GHG emissions, and support the expansion of renewable energy will help to reduce these emissions over time.

Recommendations

1. Complete another community-wide, sector-based GHG inventory in two to five years to assess progress resulting from implemented actions.
2. Use methodologies that will facilitate comparison with the 2021 results to provide an understanding of levels and trends.
3. Complete a local government operations (LGO) inventory on the same timeline as the community-wide. An LGO inventory takes a closer look at the emissions produced from municipal operations.
4. Continue to implement actions and activities that are designed to reduce GHG emissions.

Summary

The Intergovernmental Panel on Climate Change (IPCC) states that to meet the Paris Agreement commitment of keeping warming below 1.5°C we must reduce global emissions by 50% by 2030 and reach climate neutrality by 2050. Reducing global emissions by 50% requires that high-emitting nations reduce their emissions by more than 50%. More than ever, it is imperative that countries, regions, and local governments set targets that are ambitious enough to significantly reduce carbon emissions.

In October of 2020, the Salem City Council adopted the following ambitious emissions reduction goals:

- **50% reduction (from 2016 baseline) by 2035**
- **Carbon neutral by 2050**

In response to these goals, the Salem Climate Action Plan was developed, and efforts to reduce greenhouse gases from the Salem community have begun. This 2021 inventory provides an updated look at the sources of these emissions and will help the City prioritize among many potential activities contained in the Climate Action Plan. Salem will continue to track key energy use and emissions indicators on an on-going basis.

This inventory shows that transportation, electricity, and stationary fuel use patterns will be particularly important. Through Salem's local efforts and the work of other partners, the Salem area can achieve environmental, economic, and social benefits beyond the reduction of emissions.

Appendix: Methodology Details

Energy

Table 5: Energy Data Sources

Activity	Data Source	Data Gaps/Assumptions
Residential Electricity	PGE, Salem Electric	N/A
Commercial Electricity	PGE, Salem Electric	N/A
Industrial Electricity	PGE, Salem Electric	N/A
Residential Natural Gas	NW Naturals	N/A
Residential Alternate Fuels	US Census, EPA	N/A
Commercial Natural Gas	NW Natural	N/A
Industrial Natural Gas	NW Natural	N/A

Table 6: PG&E and Salem Electric (2021) Emissions Factors for Electricity Consumption

Emissions Factor Set	CO2 (lbs./MWh)	CH4 (lbs./GWh)	N2O (lbs./GWh)	Data Gaps and Assumptions
PGE	705	0	0	PGE emissions factor provided as CO2e and converted to CO2; due to this CH4 and N2O are 0. CH4 and N2O are included in the CO2 value.
Salem Electric	44	56	8	N/A

Transportation

Table 7: Transportation Data Sources

Activity	Data Source	Data Gaps/Assumptions
Transportation on-road	Google EIE	N/A
Public Transit	Cherriots	N/A
Rail	Amtrak, Union Pacific Railroad	N/A
Aviation	Salem Municipal Airport	N/A

For vehicle transportation, it is necessary to apply average miles per gallon and emissions factors for CH4 and N2O to each vehicle type. The factors used are shown in Table 8. These factors are sourced from the U.S Energy Information Administration (EIA).

Table 8: MPG and Emissions Factors by Vehicle Type

Fuel	Vehicle Type	MPG	CH4 (g/mile)	N2O (g/mile)
Gasoline	Passenger car	24.1	0.0183	0.0083
Gasoline	Light truck	17.6	0.0193	0.0148
Gasoline	Heavy truck	5.4	0.0785	0.0633
Gasoline	Motorcycle	24.1	0.0183	0.0083
Diesel	Passenger car	24.1	0.0005	0.001
Diesel	Light truck	17.6	0.001	0.0015
Diesel	Heavy truck	6.4	0.0051	0.0048
Diesel	Heavy truck	6.4	0.0051	0.0048

Wastewater

Table 9: Wastewater Data Sources

Activity	Data Source	Data Gaps/Assumptions
Effluent Discharge	City of Salem	N/A
Wastewater Facility Digester	City of Salem	N/A

Solid Waste

Table 10: Solid Waste Data Sources

Activity	Data Source	Data Gaps/Assumptions
Residential Waste	Marion County and Mid-Valley Garbage & Recycling Association	2016 and 2021 data collection methods were not comparable. 2016 was re-calculated using population difference between the two years
Commercial Waste	Marion County and Mid-Valley Garbage & Recycling Association	2016 and 2021 data collection methods were not comparable. 2016 was re-calculated using population difference between the two years
Industrial Waste	Marion County and Mid-Valley Garbage & Recycling Association	2016 and 2021 data collection methods were not comparable. 2016 was re-calculated using population difference between the two years
Landfill Gas Flaring and Combustion	Marion County and Mid-Valley Garbage & Recycling Association	2016 and 2021 data collection methods were not comparable. 2016 was re-calculated using population difference between the two years
Composting	Marion County and Mid-Valley Garbage & Recycling Association	2016 and 2021 data collection methods were not comparable. 2016 was re-calculated using population difference between the two years

Fugitive Emissions

Table 11: Fugitive Emissions Data Sources

Activity	Data Source	Data Gaps/Assumptions
Natural gas pipeline network	NW Naturals	N/A

Inventory Calculations

The 2021 inventory was calculated following the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC) and ICLEI's ClearPath Climate Planner tool software. As discussed in Inventory Methodology, the IPCC 5th Assessment was used for global warming potential (GWP) values to convert methane and nitrous oxide to CO2 equivalent units. ClearPath Climate Planner tool's inventory calculators allow for input of the sector activity (i.e. kWh or VMT) and emission factor to calculate the final carbon dioxide equivalent (CO2e) emissions.