City of Tualatin

Community Greenhouse Gas Inventory

Acknowledgements

Project team

Maddie Cheek, Management Analyst, Public Works, City of Tualatin
Nic Westendorf, Deputy Public Works Director, City of Tualatin

Special thank you to Oregon Department of Transportation, Oregon Department of Environmental Quality, and Portland General Electric, Northwest Natural, Constellation, and Calpine Energy for providing necessary data for this inventory.

Consulting team

Good Company, a sustainability consulting firm based in Eugene, OR conducted the analysis for the City of Tualatin. Beth Miller, Claudia Denton, and Aaron Toneys of Good Company provided data gathering assistance to City staff and facilitated the use of Good Company's Carbon Calculator for Communities (G3C – Community), a proprietary GHG inventory tool, to conduct analysis. They are the primary authors of this report.

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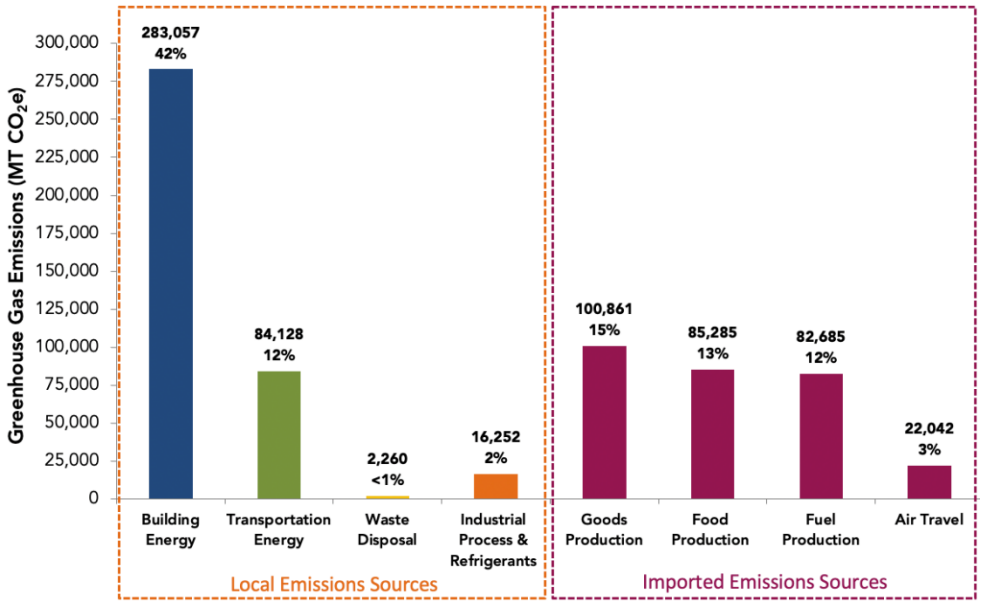
Executive Summary

The City of Tualatin completed a Community Greenhouse Gas (GHG) Inventory to better understand sources of GHG emissions (i.e., climate pollution) to inform development of a community climate action plan (CAP). The inventory follows internationally recognized community GHG inventory protocols and accounts for all significant sources of GHG emissions driven by activities taking place within the City of Tualatin's geographic boundary. Beyond protocol requirements, the inventory also measures consumption-based emissions from imported goods and food, air travel, and the purchase of carbon offsets.

Summary of Findings

- During 2019, with a population of **27,135,** all emissions combined (local and imported emissions) totaled **nearly 677,000 MT CO_2e**, or an average of **25 MT CO_2e** per resident.
- Of this, local emissions totaled nearly **386,000 Metric Tons of carbon dioxide equivalent (MT CO_2e),** or an average of **14 MT CO_2e** per resident.
    - The largest sectors were **energy use by buildings** (primarily electricity and natural gas use, 73%) and **transportation** (primarily gasoline combustion, 22%). **Industrial processes and refrigerants** accounted for 4% and **waste disposal** accounted for 1% of local emissions.
    - Commercial electricity made up **45%** of building and **33%** of local emissions.
- Imported emissions from household consumption and production of fuel and energy sold in Tualatin totaled **over 290,000 MT CO_2e** and include upstream emissions from production of goods (35%), food (29%), fuel production (28%), and air travel (8%).

Figure 1: City of Tualatin's 2019 GHG Emissions



Introduction

Human activity in the form of consumption of fossil fuels is the primary cause of global warming and changes in climate that have occurred over the past few decades and accelerated in recent years.[1] The best available evidence indicates that human-caused greenhouse gas (GHG) emissions must be reduced significantly by 2030 to avoid "severe, pervasive and irreversible impacts for people and ecosystems."[1] We are already observing physical changes to Oregon's climate, including hotter temperatures, drought, wildfire smoke, and less mountain snow[2]. Understanding the areas of greatest risk gives us the opportunity to act, rather than react, to these changing conditions and helps us be as resilient as possible. The most common international goal to mitigate the worst climate impacts aligns with the Paris Climate Accord, which seeks to limit global average temperature increases to 1.5°C (2.7°F) relative to temperatures at the start of the Industrial Revolution. As of 2018, we've already passed the halfway point: average temperatures have increased by more than 1°C (1.8°F) since the Industrial Revolution and are on track to increase to 1.5°C (2.7°F) by 2040[1].

It is with this understanding and urgency that The City of Tualatin commissioned this community greenhouse gas (GHG) inventory and chose a target of 1.5°C in alignment with the Paris Climate Accord. The City of Tualatin's 2019 Community GHG Inventory includes the following emissions sources:

Building Energy use by residential, commercial, and industrial buildings and facilities represents a large source of community emissions. These emissions come from combustion of natural gas and from electricity generated from fossil fuels to heat water and power buildings. Small quantities of combusted propane and other fuels are also included. Additionally, a fraction of natural gas is lost during local distribution, releasing methane, a potent greenhouse gas pollutant.

Transportation energy, particularly on-road vehicle transportation of passengers and freight, also represents a large fraction of community emissions. Transportation emissions are generated at the tailpipe by combustion of gasoline, diesel, other liquid and gas fuels, or from electricity generation for electric vehicles.

Waste disposal in landfills and **wastewater** treatment produces methane, of which a fraction leaks out to the atmosphere, having a negative climate impact.

Industrial Process & Refrigerants Refrigerant emissions come from transportation and building cooling systems. Refrigerants are powerful global warming gases. Therefore, relatively small losses have a large climate impact. Known, significant industrial process emissions are also included here. These emissions are not from the energy used in a factory, for example, but from the other processes involved in manufacturing. In inventory protocol, this is referred to as Industrial Process and Product Use.

[1] Intergovernmental Panel on Climate (2014). Assessment Report 5 Synthesis Report: Climate Change 2014. http://www.ipcc.ch/report/ar5/syr/

[2] Mote, P.W., J. Abatzoglou, K.D. Dello, K. Hegewisch, and D.E. Rupp, 2019: Fourth Oregon Climate Assessment Report. Oregon Climate Change Research Institute. occri.net/ocar4.

Agriculture, Forestry, & Land Use generate emissions from agricultural activity (e.g., animal waste and agricultural inputs) and community land use change (e.g., development of forest or grasslands). *These emissions are not a significant factor for Tualatin.*

Consumption-based Emissions are generated outside of the community during the production of goods, food, fuels, and service products consumed by residents. Note: *Consumption-based emissions presented in this inventory are* ***estimated (see Appendix D for more information)*** *and therefore the results have a greater level of uncertainty compared to other sources of emissions.*

What's Included? (Boundaries & Methodology)

Protocol and Inventory Boundaries

This community inventory follows Greenhouse Gas Protocol's Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC).[3] The GPC focuses on accounting for sector-based emissions, which can be thought of as local sources of emissions. This inventory also includes an estimate of the emissions embodied in local consumption of consumer goods, construction materials, and food, to inform community climate action planning. Consumption of consumer goods is a large emissions source, but it is often excluded from inventories.

The first step in any GHG inventory is setting the inventory boundary. The boundary includes defining the geographic area, time span, emissions sources and gases covered in the inventory. The greenhouse gas inventory presented in this report is based on data from calendar year 2019 for the City of Tualatin's city limits. 2019 was used as the baseline year because it was the last "normal" year before the COVID-19 pandemic occurred. However, available data was collected for years 2018-2021 in order to assess trends over a short time period. This inventory considers all seven recognized greenhouse gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). All gases are reported in terms of carbon dioxide equivalent (CO_2e), or the amount of carbon dioxide it would take to create the same warming effect.

Scopes

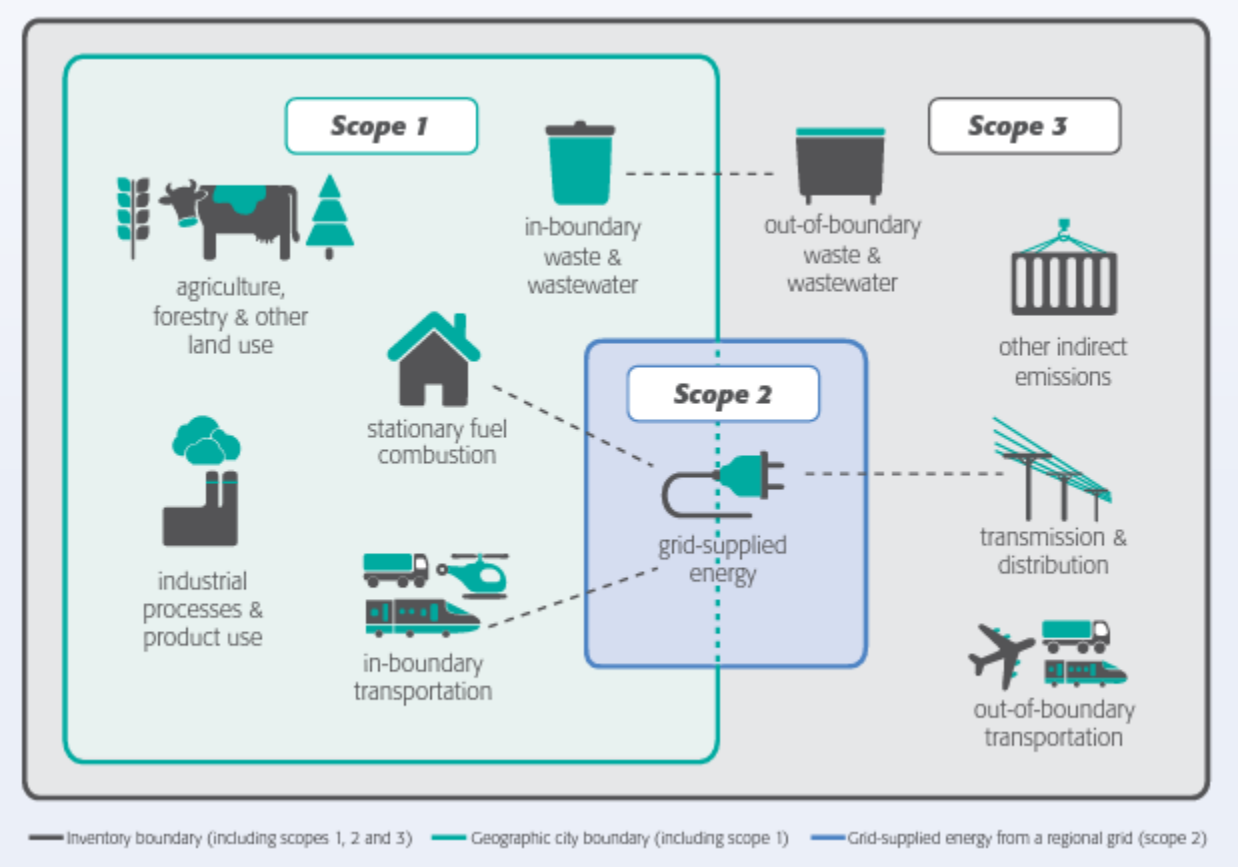
As described above, GHG emissions are often organized by sector (e.g., buildings, transportation, waste, etc.). Another way to organize them is by their origin location, either within a community or outside – these are referred to as *scopes*. Scope categories, as outlined in **Table 1** and **Figure 2** (next page) distinguish between those emissions that occur within the geographic boundaries (Scope 1) from those that occur outside the boundaries, but that are driven by activity from within the geographic boundary (Scope 2 and Scope 3). Emissions sectors and sub-sectors included in the GPC are shown in **Table 2** (page 9). These are compared to emissions included in the 2019 community inventory by scope category.

[3] GPC has become the recommended or required standard for international reporting to CDP's Cities Survey and the Global Covenant of Mayors for Climate & Energy. The GPC may be downloaded at https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities.

Table 1: Scope descriptions

Scope 1	GHG emissions from sources located within the geographic boundary.	E.g., Burning of fossil fuels to heat homes or power cars
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity within the geographic boundary.	E.g., Emissions from coal and natural gas power plants
Scope 3	All other GHG emissions that occur outside the boundary as a result of activities taking places within the boundary.	E.g., Production of fuels, goods, and food

Figure 2: A graphical illustration of scopes[4]



[4] Global Protocol for Community-Scale Greenhouse Gas Inventories

Table 2: Crosswalk of Emission and Scope Categories.

Emissions Sector / Sub-Sector	Included in Inventory	Scope 1	Scope 2	Scope 3
Stationary Energy (Buildings)				
Residential Buildings	•	✓	✓	
Commercial Buildings and Facilities	•	✓	✓	
Industrial Facilities	•	✓	✓	
Energy Generation Supplied to the Grid	NE			
Agriculture, Forestry, and Fishing	NO			
Fugitive Emissions from Natural Gas Systems	•	✓		
Fugitive Emissions from Coal Production	NO			
Transportation				
On-Road Passenger and Commercial Vehicles	•	✓	✓	✓
On-Road Freight Vehicles	•	✓		✓
On-Road Transit Vehicles	•	✓	✓	✓
Off-Road Vehicles and Equipment	•	✓		✓
Aviation	NO			
Waterborn Navigation	NE			
Waste & Wastewater				
Solid Waste	•			✓
Wastewater Treatment	•			✓
Biological Treatment of Waste	•			✓
Incineration of Waste	NO			
Industrial Process and Product Use				
Product Use (refrigerants)	•	✓		
Industrial Processes	•	✓		
Agriculture, Forestry, and Land Use				
Livestock	NO			
Land	NO			
Other Agriculture	NO			
Other Scope 3 Emissions Sources				
Household Consumption	•			✓
Air Travel	•			✓
Upstream Energy Production	•			✓
Negative Emissions (Sequestration & Offsets)				
Purchased carbon offsets	•	✓		

NE = Emissions occur but are not reported or estimated - see justification in exclusions
NO = Activity or process does not occur within boundary

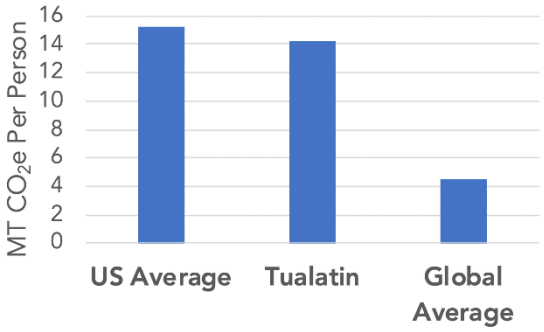
Inventory Results

Local Emissions

The Tualatin community generated nearly **386,000 MT CO_2e** of local emissions – about **14.2 MT CO_2e** per resident. **This is less than the U.S. average of 15.2 MT CO_2e per person and considerably greater than global average of 4.5 MT CO_2e per person (Figure 3).**[5] Protocols refer to local emissions as sector-based emissions. Those emissions are generated close to home and are most often under the community's direct control. **This quantity of GHGs is equivalent to the carbon sequestered by over 457,000 acres of average U.S. forest[6] - a land area about 85 times the size of Tualatin.**

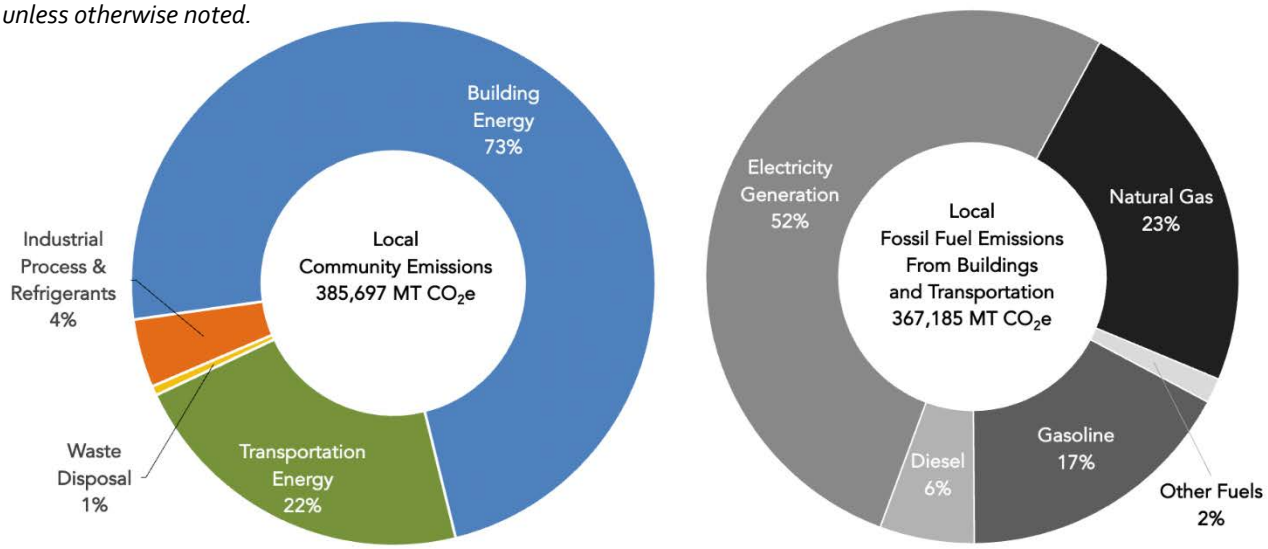
Definition: MT CO_2e
Metric Tons of carbon dioxide equivalent – a unit of measure. Most greenhouse gases are more potent in warming the atmosphere than carbon dioxide. To calculate and compare emissions easily, all gases are calculated and combined into a carbon dioxide equivalent, typically measured in metric tons.

Figure 3: Comparison of per person emissions



Tualatin's local emissions are shown on the left side of **Figure 4** and come primarily from Building Energy, such as electricity use and combustion of natural gas by buildings and other facilities (**blue segments**) and transportation sources, mainly gasoline and diesel combustion in vehicles (**green segment**). Emissions from Industrial Process & Refrigerants include federally reported special industrial emissions and

Figure 4: 2019 Local Community Emissions and Fossil Fuel Details, which come from building and transportation energy. *Note: All figures present market-based accounting for electricity emissions unless otherwise noted.*



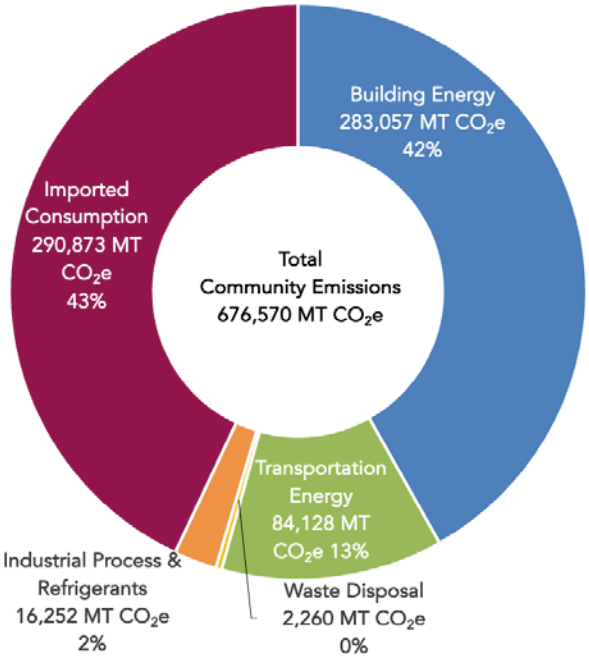
[5] Data from World Bank. For details visit https://data.worldbank.org/indicator/EN.ATM.CO2E.PC
[6] US EPA GHG Equivalencies Calculator https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

refrigerant gas loss from buildings and vehicles (**orange**). Waste emissions include landfill disposal of community solid waste and wastewater treatment (**yellow**). In Tualatin, there are no calculated emissions from Agriculture, Forestry, and Land Use. The right side of Error! Reference source not found. details fossil fuel use. Note that all emissions from **buildings** and **transportation** are from **fossil fuels** (**95% of total**); **waste** and **industrial process and refrigerants** are non-fossil fuel emissions. Although all building energy emissions are from fossil fuels, that does not mean that all building electricity is from fossil fuel sources. Electricity generated from zero carbon sources, such as hydropower, does not contribute to the city's emissions.

Imported Emissions

In addition to accounting for local emissions, the inventory also estimates **imported (consumption-based) emissions**, which are generated outside of Tualatin to produce and provide the imported **goods, food, services, air travel,** and **production and transport of fuels** consumed by local households. Imported emissions total **about 290,000 MT CO_2e** in addition to sources of local emissions. **This quantity of GHGs is equivalent to the carbon sequestered by nearly 343,000 acres of average U.S. forest[7], an area 3.7 times the size of the City of Portland. Figure 5** compares the scale of local, sector-based emissions to imported emissions from household consumption, while **Figure** 6 on the following page shows another comparison

Figure 5: 2019 Community Local + Imported Emissions



Within **goods**, the largest purchasing categories include **vehicles & parts, appliances,** and **construction materials.** Within **food**, the largest emissions are from the **production of meats,** particularly **beef** and **lamb** products.

Upstream emissions from **fuel production** (gasoline, diesel, electricity, and natural gas) and **air travel** from flights taken by residents (regardless of airport location) are also significant sources of consumption-based emissions. For more details on these emissions, see Error! Reference source not found. and the related section on page 15.

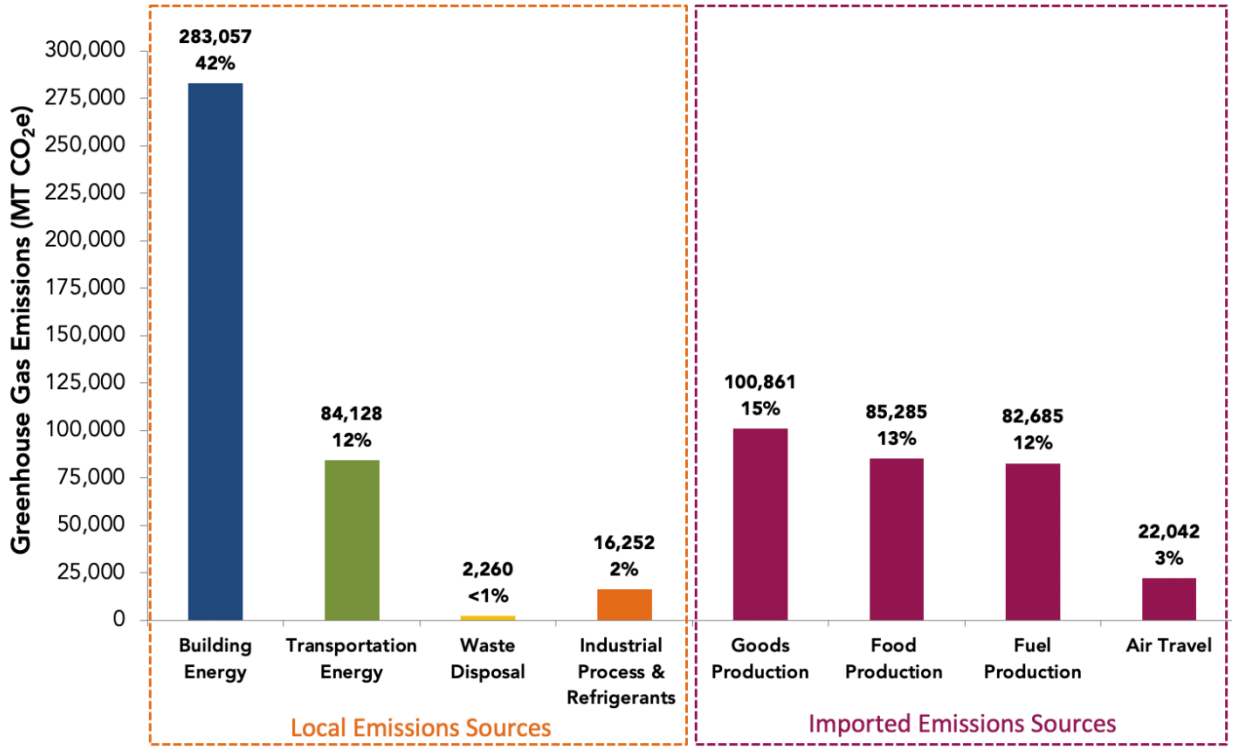
Total emissions

Local and imported emissions combine for a total nearly 677,000 MT CO_2e**, or** 25 MT CO_2e **per resident.** This quantity of GHGs is roughly equivalent to the carbon sequestered by 800

[7] US EPA GHG Equivalencies Calculator https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

thousand acres of average U.S. forest, an area roughly 4.4 times the size of Crater Lake National Park[8]. There are net **negative emissions** sources as well, from voluntary purchase of **carbon offsets** from Northwest Natural Gas customers (**over 640 MT CO_2e**). Note that the net benefit from Portland General Electric (PGE) customers' purchase of Renewable Energy Credits is already accounted for in the building energy sector (market-based accounting) and reduced emissions by **over 12,000 MT CO_2e.**

Figure 6: Tualatin's emissions sources and offsets



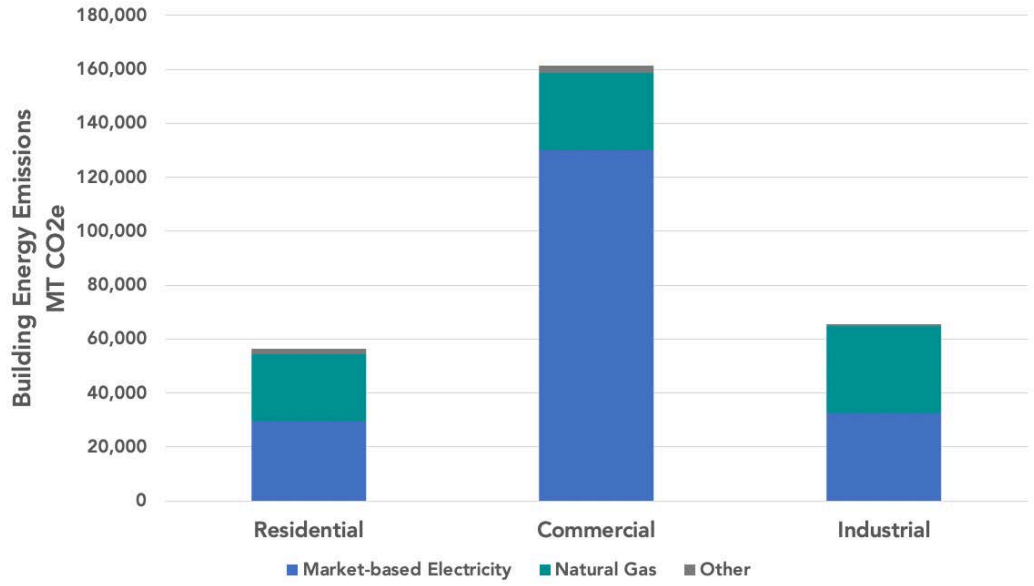
[8] National Park Foundation https://www.nationalparks.org/connect/explore-parks/crater-lake-national-park

Inventory Highlights

Building Energy

Energy used in buildings is Tualatin's largest source of local GHG emissions accounting for **73%** of local emissions. These emissions come from a mix of electricity, natural gas use, and other stationary combusted fuels and come to over **283,000 MT CO_2e**.[9] See Appendix D: Summary of Data and Emissions Factors on page 31 for more information on building energy data sources and reporting accuracy. Tualatin's commercial and industrial uses (**227,000 MT CO_2e**) have more than four times the impact of residential uses (**56,000 MT CO_2e**), over half from commercial electricity use. By energy type, electricity had the largest impact (68% of total building emissions); followed by natural gas (30%); and other fuels (2%). **Figure 7** shows emissions by sub-sector and energy type. Fugitive natural gas escaping from local distribution systems was reported by Northwest Natural and accounts for 0.3% of total building emissions (not visible in the graphic due to small scale). Emissions from electricity usage for wastewater processing are included in the Industrial category and make up 3.5% of those emissions.

Figure 7: Building Energy Usage by Type and Energy Source



The City of Tualatin has installed solar panels that generated nearly 12,000 kWh of electricity to supplement city usage. This solar energy displaced roughly 5 MT CO_2e.

Portland General Electric (PGE) supplies electricity to the Tualatin community. Each electric utility has its own specific emissions factor (MT CO_2e emitted per kilowatt-hour [kWh] of electricity) which is dependent on the utility's power generation supply contracts. In 2019, PGE's emissions factor was 0.42 MT CO_2e per megawatt-hour, a 17% decrease since 2010, meaning that the carbon intensity of electricity

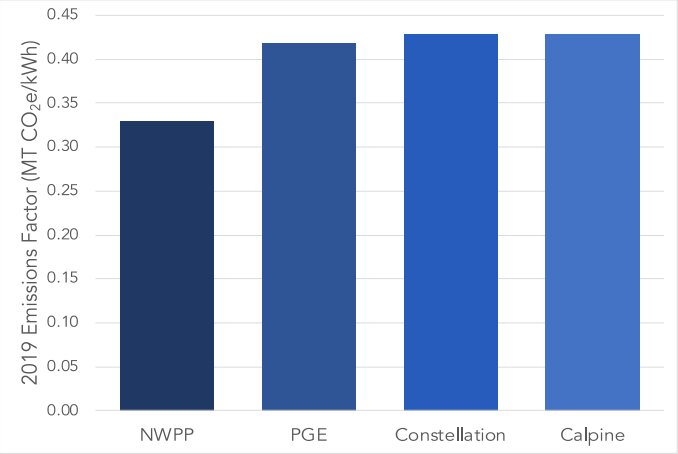
[9] All emissions estimates use market-based accounting for electricity unless otherwise noted. Market-based electric accounting totals **283,057 MT CO_2e**, while location-based accounting totals **249,866 MT CO_2e**. See Appendix C page Electricity for information about market-based vs. location-based accounting.

generation decreased over time. The market-based electricity accounting method uses utility-specific factors and accounts for voluntary community participation in utility-sponsored green power programs.

In 2019, PGE's residential and businesses customers in Tualatin purchased renewable energy in the form of Renewable Energy Credits (RECs) equal to about 6% of demand, which decreased market-based electricity accounting emissions by 12,015 MT CO_2e.

Large users may also choose to buy power from other utilities, which will have different emissions factors. In Tualatin, there are two outside utilities with contracts within the city, Calpine and Constellation energy. Figure 8 contrasts the emissions factors for the region (NWPP) with those for PGE, Constellation, and Calpine.

Figure 8: Electricity Emissions Factors

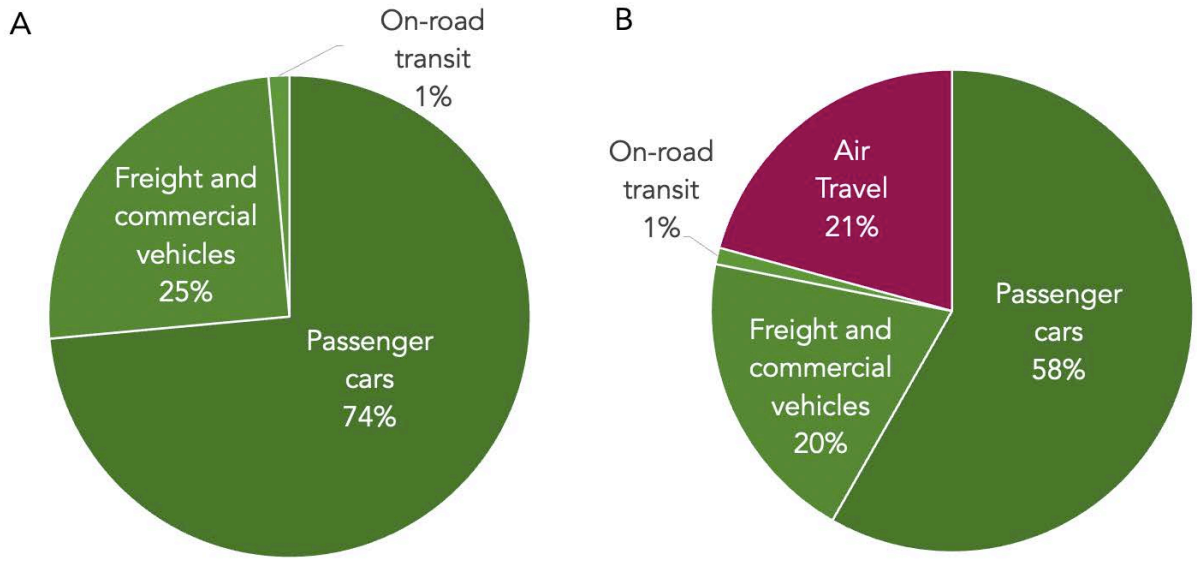


Transportation

Transportation emissions are the second largest source of local emissions for Tualatin, totaling over **84,000 MT CO_2e**. See Appendix D: Summary of Data and Emissions Factors on page 31 for more information on transportation emissions data sources and reporting accuracy. On-road passenger vehicles were the leading source of local transportation emissions and are responsible for **74%** of local transportation emissions. These emissions originate from fossil gasoline sales, primarily used by private use cars and trucks, but may include a small percentage of non-road uses such as small boats. This category also includes the small amount of electricity used by electric vehicles (**<1%**). The next largest category is fossil diesel sales, primarily used by freight and commercial vehicles at **25%**; the majority of these emissions are expected to be from on-road vehicles but may also include non-road equipment. Additionally, emissions from TriMet's public transit services were estimated to be **1%**. There were no known offroad fuel sales, although some of the fuel sales probably went to offroad uses (such as gasoline powered lawnmowers). See **Figure 9**.

Tualatin does not have an airport within the geographic boundary so there are no local air travel emissions, but many residents do travel by airplane, and air travel is part of the community's **consumption-based emissions**. As is shown in **Figure 9**, emissions from air travel (**magenta**) are a significant source of emissions in addition to local transportation emissions (**green**). Consumption-based air travel emissions are estimated at just over **22,000 MT CO_2e**. See Appendix D: Summary of Data and Emissions Factors on page 31 for more information on air travel data sources and reporting accuracy.

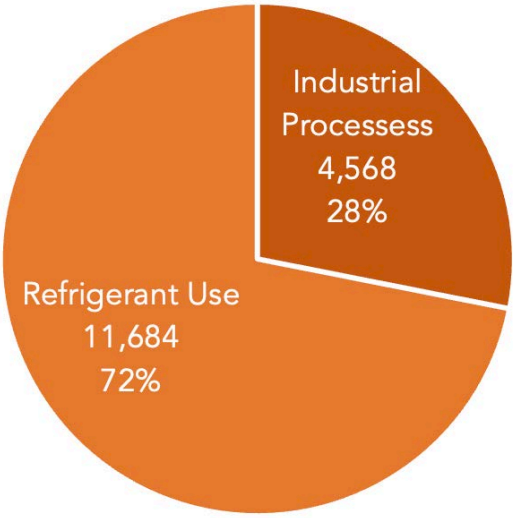
Figure 9: Transportation emissions breakdown. A: Tualatin's transportation emissions excluding air travel, B: Tualatin's transportation emissions including air travel



Industrial Process and Refrigerants

Industrial Process and Refrigerant (IPR) emissions are the third largest source of emissions. IPR emissions are fugitive emissions; unintentional emissions, leaks, or discharges of gases and vapors from pressurized equipment or facilities. They come from specialized industrial uses or refrigeration systems – CFCs, HFCs, PFCs, SF_6, and NF_3 – and have a large climate impact, up to 23,500 times the Global Warming Potential of an equivalent weight of CO_2 depending on the gas.

Figure 10: IPR Emissions



Fugitive loss of refrigerants from residential and commercial buildings and vehicle air conditioning and refrigeration equipment are the largest proportion of Tualatin's IPR emissions. These sources are estimated for Tualatin using state per capita data, downscaling from emissions reported in the State of Oregon's 2015 GHG Inventory, and are estimated at about **12,000 MT CO_2e**. Within the State of Oregon, sources of residential, commercial, and transportation refrigerant emissions (in DEQ's inventory as High Global Warming Potential gases) have grown by 21% since 2009[10].

Industrial process emissions (excluding energy use) were identified for one facility within Tualatin using the Oregon Department of Environmental Quality reported greenhouse gas emissions for facilities with

[10] Oregon Greenhouse Gas Sector-Based Inventory https://www.oregon.gov/deq/aq/programs/Pages/GHG-Inventory.aspx

air quality permits[11]. These emissions total close to **5,000 MT CO_2e**[12] for 2019. See Appendix D on page 31 for more information on industrial process and refrigerants data sources and reporting accuracy.

Solid Waste & Wastewater

Solid Waste and Wastewater emissions total less than **2,500 MT CO_2e** – less than 1% of local emissions. Tualatin haulers send landfilled waste to Arlington Landfill (Eastern Oregon), Wasco Landfill (Eastern Oregon), and Coffin Butte landfill (Western Oregon). These landfill emissions are estimated to total roughly **1,600 MT CO_2e**.

Wastewater is processed by Clean Water Services and is included in the analysis. A negligible number of septic systems are located in the city. Total wastewater process emissions, not including septic, are estimated to total **about 675 MT CO_2e**. See Appendix D on page 31 for more information on data sources and reporting accuracy related to solid waste and wastewater treatment.

Imported Emissions

Emissions from Consumption of Imported Goods, Food, Fuel, and Air Travel

Tualatin's inventory goes beyond GPC protocol requirements to highlight the known large sources of imported emissions from consumption activities. These emissions are considered Other Scope 3 in GPC protocol. This means the community has less control over management of these emissions as compared to sources of local emissions. These consumption-based emissions will be in another community's local accounting. That said – these emissions are included in the inventory because they are large, they are caused by local demand, it follows State of Oregon inventory practices, and because opportunities exist to reduce these emissions locally by reducing consumption. These emissions were estimated at nearly 290,000 MT CO_2e and make up 43% of total **emissions (Figure 11).** See Appendix D on page 31 for more information on sources and reporting accuracy for imported emissions, including goods, food, services, and upstream fuel production.

[11] Available at https://www.oregon.gov/deq/aq/programs/Pages/GHG-Emissions.aspx

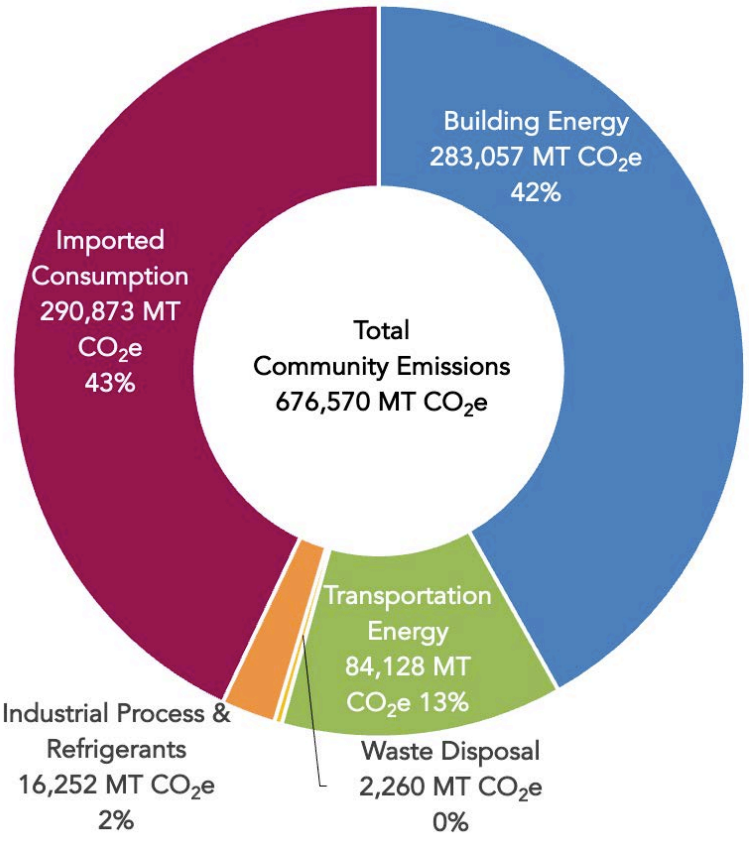
[12] These facilities are monitored by EPA's FLIGHT and/or Oregon DEQ due to the significant climate impacts. EPA's FLIGHT database values will vary from this analysis, as the online tool uses IPCC AR4 GWP values, and this GHG Inventory uses updated IPCC AR5 GWP values in line with the most recent science. Oregon DEQ also reports AR4 GWP values, but individual gas data was not available to convert into AR5 GWP value totals. Applicable Industrial Process emissions data for Microchip Technologies and ON Semiconductor was calculated from EPA FLIGHT. Applicable Industrial Process emissions data for Owens Corning Corp. was requested from Oregon DEQ. Building energy was excluded.

Consumption of imported **goods** is the largest source for Tualatin's imported emissions at **35% of imported emissions.** The largest contributors to this category **include building materials, vehicle parts,** and **furnishings and supplies**Error! Reference source not found.**.** The next largest category is **food** and beverage, where largest emissions are from **meat**, specifically **beef** and **lamb** products. Upstream **fuel production**, specifically gasoline production, is another large source, which goes hand-in-hand with passenger transportation being a large local emissions source. Air travel is also a significant source of Tualatin consumption-based emissions. Note that these air travel emissions are from air travel trips taken by residents regardless of airport location and are not based on Portland airport fuel use alone.

Category Descriptions

- **Goods:** Emissions from extraction, manufacture, and transportation of raw materials into final products such as building materials, automobile, furniture, clothing, and other goods.
- **Food & Beverage:** Emissions from agriculture (energy for irrigation, production of fertilizers, methane emissions from livestock, etc.), transportation of raw materials, and finished products emissions. Categories include produce, cereals, dairy, meat, and other foods.

Figure 11: 2019 Community Local + Imported Emissions



- **Upstream Fuel Production:** Process and energy emissions from the extraction and production of usable fuel products (e.g., electricity from household outlets, gasoline pumped into cars, natural gas combusted by furnaces, etc.). These upstream emissions are considered at the

community-scale for electricity, natural gas, gasoline, and diesel (not available for propane and fuel oil). These emissions are separate from those that are generated when the fuel is used in your car or house.

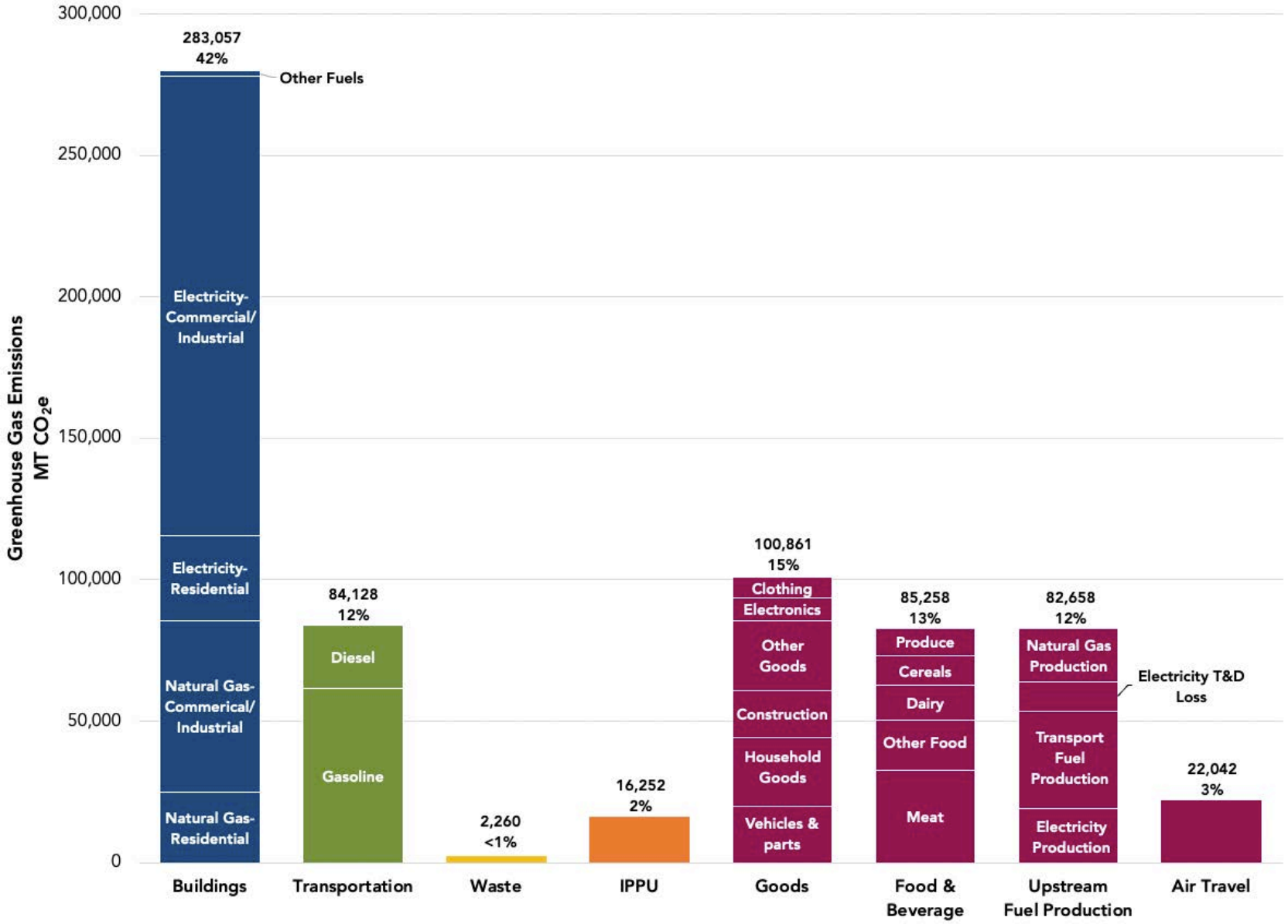
- **Air Travel:** Emissions associated with air travel by the community (regardless of the airport's location).

Figure 12 on the following page gives a full categorical breakdown of all emissions

Negative Emissions

Negative emissions are from carbon offsets purchased by natural gas consumers. Less than 1% of the natural gas used in Tualatin is offset by community members who participate in Northwest Natural's Smart Energy Offsets program (**664 MT CO_2e**). This program allows customers to purchase carbon offsets from The Climate Trust on their bill to offset emissions from their natural gas use. See Appendix D on page 31 for more information on carbon offset data sources and reporting accuracy.

Figure 12: Full breakdown of emissions categories

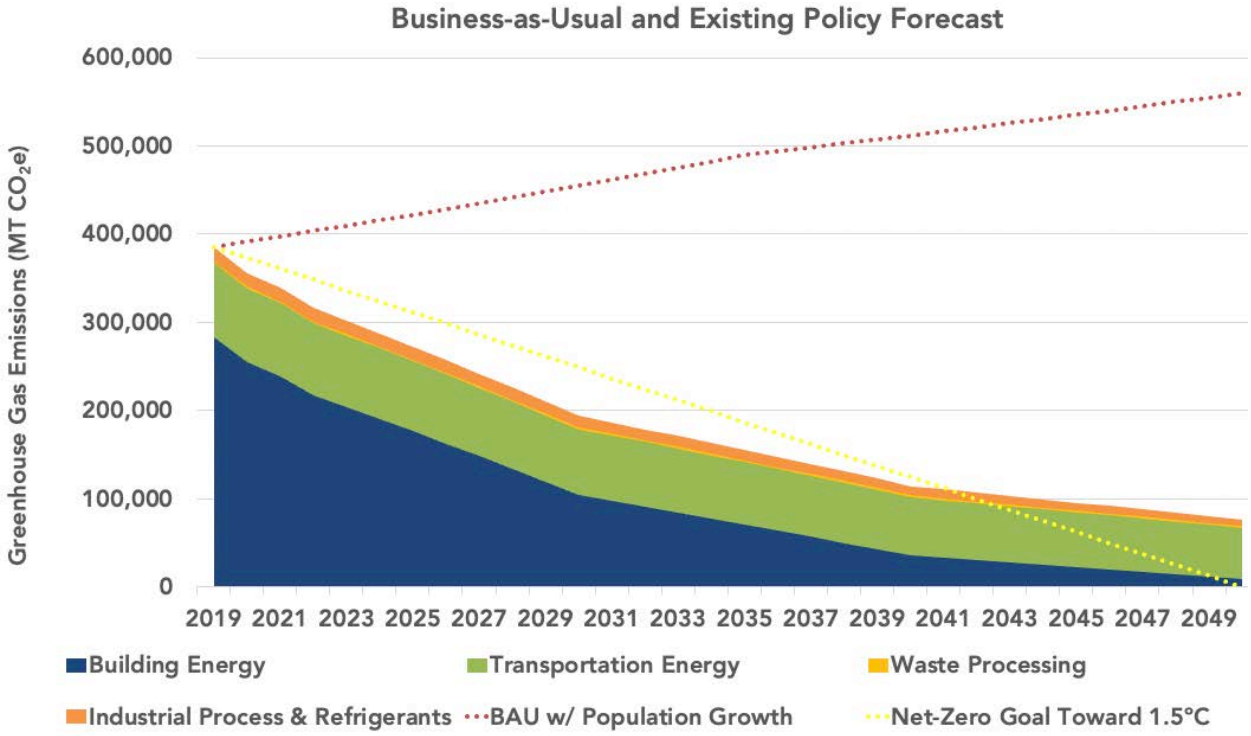


Local Emissions Forecast & the Paris Accord Climate Goal

Local emissions in Tualatin are expected to decrease over time, primarily thanks to strong climate action from the State of Oregon in the stationary energy sector. The Oregon Clean Energy Targets, Oregon Climate Protection Program, as well as specific data from PGE and Northwest Natural, were reviewed for modeling stationary energy emissions reductions and are expected to reduce emissions from electricity, natural gas, and other stationary fuels by 97% in 2050. Additionally, state and federal policy impacting transportation, refrigerants, and waste emissions are included here. **While emissions are estimated to decrease by 80%** in 2050 compared to 2019 local emissions without additional mitigation actions, **that is still not enough to hit our target of 100% GHG emissions mitigation to limit global warming to 1.5ºC.**

Additional goals and actions beyond current projections and legislation will be modeled as part of the community Climate Action Plan to help meet our target. Figure 11 shows forecasted emissions by sector (colored wedges) are compared to forecasted growth based on population growth only (dotted red line) and the Paris Accord 1.5°C warming goal of net-zero emissions by 2050 (yellow dotted line).

Figure 13: Tualatin's Business-as-Usual Forecast (red, population growth with no policy interventions) with Forecasted Emissions Based on Existing State and Federal Policy, and a Net-Zero by 2050 Trajectory (yellow dotted line)



Thanks to the existing state and federal policies impacting GHG emissions, Tualatin can expect a reduction of 80% of local emissions in 2050 compared to 2019, with only about 77,000 MT CO_2e remaining, primarily from the transportation sector. For Tualatin, this is primarily from E10 gasoline sales. While policy can be difficult to detail and implement, there are approaches available to reducing

transportation GHG emissions. *More details on community climate action planning and mitigation will be detailed in the upcoming community Climate Action Plan.*

Note that imported emissions are not included in this forecast. Primarily, this is because changes in imported emissions are very challenging to track, and data is limited. Additionally, policy options are limited as the sources of emissions are local to other communities. Local emissions are more commonly used for community goal setting.

Appendix A: More Detailed Data

Table 3: Detailed Emissions Breakdown

Emissions Sector / Sub-Sector All emissions reported in MT CO_2e	2019 Emissions		Per capita	
	Market-based*	Location-based	Market-based	Location-based
Stationary Energy	283,057	249,862	0.7	0.7
Residential Buildings				
Electricity	29,490	32,118	0.1	0.1
Natural Gas	24,721		0.1	
Other Fuels	2,009		0.01	
Commercial Buildings and Industrial Facilities				
Electricity	161,311	125,730	0.4	0.3
Natural Gas	60,935		0.2	
Other Fuels	2,757		0.01	
Fugitive Emissions from Natural Gas Systems	726		0.0	
Wastewater Treatment Energy	1,108	865	0.0	0.0
Transportation	84,128	84,074	0.2	0.2
Gasoline	61,629		0.2	
Diesel	21,068		0.1	
On-Road Transit Vehicles	1,180		0.0	
Electric Vehicles	251	196	0.0	
Waste	2,917		0.01	
Solid Waste Landfill and Compost	2,242		0.01	
Wastewater Treatment & Septic Systems	675		0.00	
Industrial Process and Product Use	16,252		0.04	
Refrigerants	11,684		0.03	
Industrial Process	4,568		0.01	
Consumption-based & Upstream Emissions	290,873	285,248	0.8	0.8
Household Consumption				
Goods	100,861		0.3	
Food	85,285		0.2	
Upstream Energy Production	82,685	77,059	0.2	0.2
Air Travel	22,042		0.1	
Negative Emissions (Sequestration & Offsets)	-677		0.0	
Purchased Offsets	-677		0.0	
Local Emissions	386,355	353,104	1.0	0.9
Local + Consumption	677,228	638,352	1.8	1.7

*For an explanation of market vs location-based accounting see Appendix C: Electricity.

Table 4: Available data over multiple years

Available Emissions Data by Sector ($MT CO_2e$ / year)	2018	2019	2020	2021
Building Energy				
Electricity (Market-Based)	*No Data*	191,909	169,193	153,445
Natural Gas	81,314	85,655	80,702	*74,402*
Other Fuels *	4,942	4,767	4,587	4,587
Transportation				
Gasoline (E10)	66,886	62,809	63,002	82,319
Diesel (B5)	18,533	21,068	21,725	27,382
Electric Vehicles (Market-Based)	153	251	331	607
Waste				
Landfilled Solid Waste	849	2,242	1,098	1,418
Wastewater Treatment Process	742	675	683	695
Process & Fugitive Emissions				
Refrigerant Loss **	11,684	11,684	11,684	11,684
Manufacturing	7,366	4,568	5,003	*No Data*
Fugitive Natural Gas	689	726	684	*631*

* Last available data is from 2019, used as proxy for 2020 and 2021 with population adjustments.

** Data estimated from statewide averages and scaled down for population.

Appendix B: Glossary of Terms

GHG

Short for greenhouse gases. Emission of greenhouse gases are the cause of current climate change. An inventory of GHGs measures gases in units of carbon dioxide equivalents (CO_2e). A GHG inventory is also known as a carbon footprint.

GHGP/GPC/Protocol

This type of inventory follows a set protocol, the GHG Protocol (GHGP) standard for cities and communities known as Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). This protocol determines what is included within a set boundary and categorizes emissions by sector. See Sector-based inventory for more information.

GWP

Short for global warming potential. This refers to the potency of emissions to trap heat in the atmosphere. Carbon dioxide has a GWP of 1, and other GHG gases are more potent and expressed as a multiple of carbon dioxide. For example, methane has a GWP of 28, meaning one molecule has 28 times the effect of one molecule of carbon dioxide (IPCC AR5 values).

Imported, Consumption-based Emissions (Other Scope 3)

Emissions from consumption of imported goods and services, also known as Other Scope 3 Emissions per GPC protocol, include emissions from upstream fuel production and household consumption, such as food, household goods, and air travel.

IPCC AR5

The United Nations Intergovernmental Panel on Climate Change (IPCC) releases Assessment Reports every six to seven years providing an overview of the state of knowledge concerning climate change science. The fifth report, AR5, is the most recent version released in 2014. The 6th assessment is due to be released shortly after the production of the report.

KWh

Short for kilowatt hour. Kilowatt hours are a standard unit for electricity consumption, and a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour. For example, a 50-inch LED TV uses about 0.016 kWh per hour. It would take roughly 62.5 hours for this TV to use 1 kWh of energy[13].

Sector-based Greenhouse Gas Inventory (Local Emissions)

This refers to preparing an inventory that is broken down by various sectors of the community that have common GHG characteristics. In this report, sector-based emissions are also known as **local emissions**. This type of inventory follows a set protocol (GPC) determining what is included in each sector. Mainly,

[13] Electricity Plans: https://electricityplans.com/kwh-kilowatt-hour-can-power/#:~:text=Here%20are%20some%20of%20the,around%202.3%20kWh%20per%20hour

sector-based emissions include emissions from building energy and vehicles along with local sources of GHGs from waste, uncontrolled loss of industrial and refrigerant gases, and agriculture. Note that emissions from household consumption of goods and services are not included in sector-based inventories. Standard sectors include:

- **Building Energy:** emissions from energy used or produced in a fixed location, e.g., electricity, natural gas, propane, and fuel oil. The GPC term is stationary energy.
- **Transportation:** emissions from vehicles and mobile equipment.
- **Waste:** landfilled waste emissions and wastewater treatment emissions.
- **Process Emissions & Product Use:** refrigerants and other fugitive gases from industrial processes.
- **Agriculture, Forestry & Land Use:** emissions from agriculture (e.g., animal waste and agricultural inputs) and community land use change (e.g., development of forest or grasslands).

Location-based Electricity Emissions Accounting

Refers to GHG intensity of the regional electricity grid, representing the average impacts of electricity use and efficiency efforts across the region. Contrast with Market-based Electricity Emissions Accounting.

Market-based Electricity Emissions Accounting

Refers to the GHG intensity of electricity contracts with local utilities. Contrast with Location-based Electricity Emissions Accounting.

MT

Short for Metric Ton (~2,200 lbs.). This is a common unit by international standards.

MT CO_2e

Metric Tons of carbon dioxide equivalent – a unit of measure. Most greenhouse gases are more potent in warming the atmosphere than carbon dioxide. To calculate and compare emissions easily, all gases are calculated and combined into a carbon dioxide equivalent, typically measured in metric tons.

Scope (as in Scope 1, Scope 2, Scope 3)

Scopes are one method to define the source of emissions. Scope categories distinguish between emissions that occur within a geographic boundary (scope 1), from electricity generation serving the community (scope 2), and emissions that occur outside the boundary, but that are driven by activity within the boundary (scope 3).

Therm

Common reporting unit of natural gas that represents 100,000 British thermal units. A therm is roughly equivalent to 100 cubic feet of natural gas.

Appendix C: Methodology & Protocols

Protocols and Tools

This inventory follows Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories by Greenhouse Gas Protocol (GHGP). This inventory also follows GHGP's Scope 2 Guidance for location-based and market-based electricity accounting emissions and ICLEI's US Community Protocol for guidance on calculation of consumption-based emissions (i.e., other Scope 3 as defined by GPC protocol).

Good Company's carbon calculator tool *G3C – Community* was used for emissions calculations. Emissions are documented in the Inventory Audit Trail. G3C – Community is an Excel-based calculator that documents all activity data; emissions factors; and emissions calculations used in the inventory. The audit trail catalogs all data, calculation, and resource files used to complete the inventory. These resources are highly detailed and will allow for those conducting future inventories to fully understand and replicate the methods used in this inventory.

GHG emissions presented in this report are represented in metric tons of carbon dioxide equivalent (MT CO_2e). The gases considered in the analysis are consistent with protocol and include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Chlorofluorocarbons (CFCs), and perfluorocarbons (PFCs) per the Kyoto Protocol (Sulfur Hexafluoride, SF_6, was not applicable). All GHG calculations use 100-year global warming potentials (GWP) as defined in the International Panel on Climate Change's 5th Assessment Report (IPCC AR5).

Data Collection

Good Company worked with Tualatin's staff to collect the data required to calculate emissions. Tualatin's staff, along with other local and regional government staff and private entities that serve the community, graciously provided time, data, and expertise. Data and emissions factors are described in Appendix D: Summary of Data and Emissions Factors.

Inventory Exclusions

Table 5: Summary of Inventory Exclusions

NE = Emissions occur but are not reported or estimated
IE = Included Elsewhere as part of another data set where a split is not available
NO = Activity or process does not occur within boundary

Emissions Sector / Sub-Sector	Key	Justification for Exclusion
Building energy: Potable Water Treatment and Delivery Energy	IE/NE	Tualatin is served mainly from the City of Portland through the Bull Run and groundwater systems. This water is gravity fed, and any additional local pumping is included in building energy. Treatment energy is not included because it occurs outside the city boundary.
Building energy: Energy Generation Supplied to the Grid	NO	No significant activity identified within Tualatin's geographic boundary. Some local community solar is likely but expected to be insignificant, with the exception of the solar generation by the city mentioned in the report.
Building energy: Agriculture, Forestry, and Fishing	NO	No activity identified within Tualatin's geographic boundary.

Building energy: Fugitive emissions from Coal Production	NO	No activity identified within Tualatin's geographic boundary.
Transportation: Rail	NE/IE	A short strip of freight rail track is located inside Tualatin. The emissions associated with this are expected to be insignificant and because there are no freight stops within the community, this can be excluded by protocol. A short section of TriMet light rail is located inside Tualatin. The community's share of transit emissions, including the WES rail, are included in on-road transit emissions.
Transportation: Aviation	NO	Aviation emissions within the GPC are specific to air travel that is confined to the Community's geographic boundary; no such activity identified within Tualatin's geographic boundary. That said – the community's air travel emissions for flights that extend beyond the community's boundaries are estimated and included as an Other Scope 3 emissions source. These emissions represent an estimate of air travel emissions by community residents for transboundary trips outside of the community's geographic boundary.
Transportation: Waterborne navigation	NO	There are no marinas along the Tualatin River where it borders the city. Any fuel use for small craft (such as fishing boats) is expected to be insignificant and likely to be included in transportation fuel sales.
Agriculture, Forestry, and Land Use	NO/NE	No livestock activity or industrial-scale agriculture activity identified within Tualatin's geographic boundary. Land Use change emissions from development is not expected to be significant, but data was not available.

Electricity

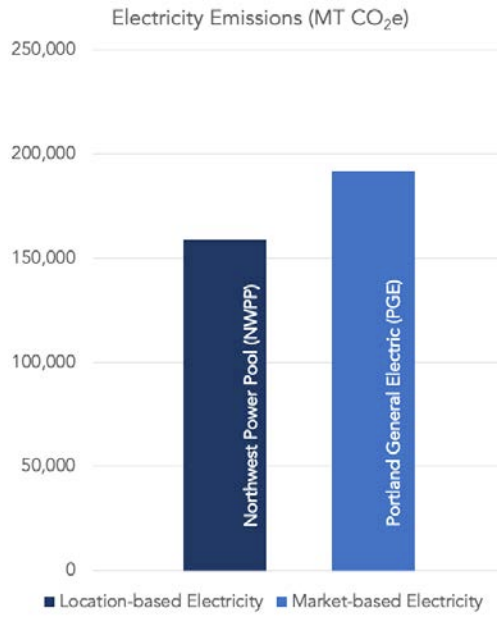
Activity data was collected from Portland General Electric (PGE). Data was collected directly from the utility, including percentage of RECs purchased. A split for commercial and industrial uses was not available.

The Community Inventory Protocol (GPC) requires that communities report electricity emissions using two accounting methods: location-based and market-based.[14] **Market-based accounting** is based on the GHG intensity of electricity contracts with local utilities and is used in most of the figures presented in this report as the GPC protocols recommended methodology to track progress towards goals over time. **Location-based electricity accounting emissions** are calculated using the regional electricity grid's (Northwest Power Pool, NWPP) GHG intensity and represent the average impacts of electricity use and efficiency efforts.

[14] For details visit http://www.ghgprotocol.org/scope_2_guidance.

- **Location-based method** (or regional grid) multiplies an organization's electricity use by the average emissions intensity of a specific regional electricity grid that is published by the Environmental Protection Agency (eGRID 2019). Note that over time there may be differences in emissions results for inventory years due to the use of an updated eGRID emissions factor (typically released every 1-2 years). Location-based electricity accounting offers a means of assessing the average impacts of electricity use on the regional electricity grid.

Figure 14: Electricity emissions using both accounting methods



- **Market-based method** (or utility-specific) represents emissions specific to the utility and takes into account community purchase of renewable energy certificates. Market-based electricity accounting is commonly used for target and goal tracking and is useful to assess and manage GHGs associated with electricity generation and supply. It also highlights benefits for energy efficiency actions, particularly in communities served by utilities with very low GHG electricity. That is, the less electricity used in the community, the more low-GHG electricity there is available for export to communities with more GHG intensive electricity sources.

Appendix D: Summary of Data and Emissions Factors

Emissions Category	Category Description
Building Energy (Stationary Energy in GPC Protocol)	
Residential Energy	*These categories include direct emissions from natural gas, fuel oil, and propane combustion by the residential, commercial, and industrial sub-sectors within the geographic boundary. Also includes the emissions from grid electricity used by the same sub-sectors for the same geographic boundary.*
Commercial Energy	
Industrial Energy	
Electricity and natural gas data provided by Portland General Electric, Northwest Natural Gas, Calpine, and Constellation Energy. Electricity and gas data included information on retail sales and participation in renewable electricity and carbon offset programs. Residential and commercial fuel oil and propane use was estimated using state-level per capita 2019 fuel usage data downscaled by Tualatin's 2019 population. Emissions factors for natural gas, fuel oil, and propane are from U.S. EPA's emissions factors hub and The Climate Registry's 2018 Default Emissions Factors and are considered highly accurate. Location-based electricity emissions factors are taken from EPA eGRID 2019 data for the Northwest Power Pool (NWPP) sub-region. Market-based electricity accounting emissions factors for electric utilities are taken from Oregon Department of Environmental Quality's report titled, *2010 – 2019 Greenhouse Gas Emissions from Electricity Use*. Available online at https://www.oregon.gov/deq/aq/programs/Pages/GHG-Emissions.aspx. Utility data is considered highly accurate; non-utility data (e.g., fuel oil and propane) is considered to have medium accuracy.	
Fugitive Natural Gas System Emissions	*Fugitive loss of natural gas from the local product distribution system.*
Northwest Natural Gas reported a 0.12% system leakage rate. Note that the NWN reported rate is less than half of the protocol default proxy value of 0.3%. This data is considered highly accurate.	
Transportation	
On-Road Energy	*Direct emissions from gasoline and diesel for passenger & freight transportation.*
Fuel sales data for gasoline, diesel, propane, and compressed natural gas (CNG) was provided by the ODOT Fuels Tax Group. It quantifies the total volume of fuel sold within city borders. This data is considered highly accurate. This is following the Fuel sales methodology from the GPC. It has the advantage of being inexpensive to collect and easy to compare across years.	
Transit	*Direct emissions from gasoline and diesel (on-road) and electricity (light rail) for passenger transit transportation.*
Emissions data was collected from TriMet Transit District's Operational GHG inventory. These emissions were estimated and downscaled by Tualatin's population to TriMet's service territory. Data	

received from TriMet is considered highly accurate; however, the estimate based on population is considered moderately accurate.	
Rail - Passenger & Freight	*Direct emissions from gasoline and diesel for passenger and freight transportation within the geographic boundary.*
WES emissions are included in transit emissions. No Amtrak or other passenger rail activity occurring in the boundary. A short strip of freight rail track is located inside Tualatin. Data was not available, and emissions are expected to be insignificant. Furthermore, most transportation emissions are based on fuel sale data, of which no fuel is sold for rail uses.	
Off-Road	*Direct emissions from gasoline and diesel for off-road vehicles such as construction equipment, etc.*
Fuel sales data for dyed diesel and biodiesel was provided by the ODOT Fuels Tax Group. This data is considered highly accurate, although there were no reported dyed fuel sales in 2019.	
Waste	
Landfill Solid Waste	*Fugitive methane emissions from mixed solid waste generated in the community regardless of disposal location.*
Tualatin has multiple destination landfills. For waste landfilled at Coffin Butte, Wasco, and Arlington landfills, EPA reported 2019 emissions were downscaled based on reported short tons from Tualatin customers. This methodology follows IPCC's first order decay model and is designated by EPA as EE-6 calculations. This activity data is considered highly accurate.	
Wastewater Treatment Process Emissions	*Fugitive nitrous oxide emissions from discharge of treated effluent (wastewater).*
Wastewater treatment plant process emissions for biogas combustion and effluent discharge are calculated using data provided by Clean Water Services staff. For biogas combustion data included square cubic feet per day of biogas and the percent methane in the biogas. For Nitrogen effluent discharge, data was not available and was estimated using ICLEI U.S. Community GHG Protocol methodology and service population. Emissions calculations for nitrification / denitrification are based on service population. This activity data is considered medium-to-highly accurate.	
Septic Systems	*Direct emissions from the combustion of biosolids (wastewater).*
Septic fugitive emissions were not estimated for this report and are expected to be minimal.	
Industrial Process & Refrigerants (Industrial Process & Product Use in GPC protocol)	

Refrigerants (Product Use in GPC protocol)	*Fugitive loss of refrigerants and other high GWP gases from building and vehicle air conditioning systems.*
Fugitive refrigerant loss and other non-industrial high GWP gas emissions are estimated using Oregon state-level data attributed to the community on a per capita basis. Activity data for state-level fugitive emissions from refrigerants, aerosols, and fire suppression systems is reported in the Oregon Department of Environmental Quality's (ODEQ's) Oregon Greenhouse Gas Inventory (as High Global Warming Potential [HGWP] sources) in quantities of CO_2e. Data used is from Oregon's GHG inventory includes HGWPs for the residential & commercial and transportation sub-sector (industrial emissions calculated separately, see Industrial Processes below). High GWP gas emissions are estimated from State of Oregon totals and therefore are considered as having mid-level accuracy.	
Industrial Processes	*Fugitive loss of industrial high GWP gases from industrial processes. Stationary building emissions (fuel combustion, etc.) are not included and are part of Building Emissions.*
Three applicable facilities inside the boundary were identified by the EPA FLIGHT tool and/or Oregon DEQ's air quality monitoring reports. These industrial facilities are required to report significant air quality and/or climate emissions. Only one of these had non-energy emissions. EPA reports include specific gases and quantities with clear separation of building energy emissions. Pre-calculated values used IPCC AR4 GWP values and were re-calculated to reflect more accurate IPCC AR5 GWP values. Building energy emissions were excluded to avoid double counting. Oregon DEQ reports total emissions in CO_2e and do not list specific high GWP gases or quantities, nor a split between Industrial Process and building energy emissions. Oregon DEQ was contacted with a request for an Industrial Process split which was provided. Emissions were reported using AR4 GWP values and were not possible to re-calculate using AR5 values. Other DEQ reported facilities either emitted biogenic emissions or 100% building energy emissions and were not included. This data is considered highly accurate.	
Imported Emissions	
Goods	*Upstream energy and process emissions raw material extraction, manufacturing, and out-of-state transportation of goods.*
Food	*Upstream energy and process emissions from the growing, processing and transportation of foods.*
Services	*Upstream energy emissions from air travel by community members from all airports regardless of location.*
Accurate data on quantities and suppliers for the goods and food consumed by community households is not readily available. Therefore, the State of Oregon's 2015 consumption-based emissions inventory (CBEI) was used to estimate these sources of emissions. State of Oregon CBEI results were downscaled for Tualatin using US Census Bureau data on households' income and number of households within various income brackets. Note that ODEQ conducts the Oregon CBEI every 5 years and therefore this	

methodology may not be used to estimate emissions on an annual basis. Emissions estimates were therefore adjusted for inflation and nationwide trends in spending between 2015 and 2019. Spending trends were taken from the Bureau of Labor Statistics.

Air travel is based on U.S. Census Data and Oregon's version of the UC Berkeley Household Cool Climate Calculator. Given the inventory year and that data is estimated from a large and complicated economic model, this activity data is considered as having mid-to-low accuracy.

Upstream Fuel Production	*Upstream energy and process emission from the production and distribution of natural gas, gasoline, diesel, and electricity consumed either directly or indirectly by the Community.*

Data for gasoline, diesel, natural gas, and electricity use is same as previously described. Lifecycle emissions factors for the various fuel types are provided by Oregon Department of Environmental Quality's Clean Fuels program carbon intensity scores. Upstream fuel and energy emissions are calculated as the difference between direct tailpipe emissions (reported under Transportation) and total lifecycle emissions. Activity data for electricity and natural gas is considered highly accurate while transportation fuel use is considered moderately accurate because the precise feedstocks for biofuels sold within the community is not readily available. Upstream emissions can vary significantly for biofuels depending on feedstocks and therefore calculated emissions are considered moderately accurate. Upstream emissions factors are for regulatory purposes and are therefore considered highly accurate.

Negative Emissions

Purchased Carbon Offsets	*Community purchase of verified carbon offsets.*

Carbon offsets purchased by Northwest Natural Gas account holders' participation in NWN's Clear Energy program were provided by the utility as therm-equivalents and MT CO_2e. This activity data is considered highly accurate.