Greenhouse Gas Inventory Report for Calendar Years 2015 – 2018 Final Report

Thurston County, Washington

June 2020

Prepared by the Thurston Climate Action Team

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Table of Contents

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Acknowledgements

This report was developed as a result of Thurston Climate Action Team's (TCAT's) Greenhouse Gas (GHG) Inventory project. Tom Crawford, TCAT President, led the effort on behalf of TCAT, and recruited Dave Bradley, retired from the Department of Ecology, to work on the project.

Tom Crawford is one of the founders of TCAT and has served on TCAT's board since 2009. He holds a bachelor's degree in philosophy from Gonzaga University, and a Master's in Education (M. Ed.) from Eastern Washington University. Tom's background includes work with local and state governments nationwide to improve processes and automated systems, and with Native American communities throughout the Pacific Northwest on community development and educational projects.

Dave Bradley worked for the Department of Ecology for thirty years as a toxicologist and manager in the Toxics Cleanup, Air Quality and the Shorelands and Environmental Assistance Programs. Prior to joining Ecology, Dave worked in Washington DC for an environmental risk assessment consulting firm and the Ralph Nader organization. He holds an undergraduate degree in environmental engineering and a Master's in Toxicology, both from the University of Michigan.

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Executive Summary

Lacey, Olympia, Tumwater and Thurston County are preparing a regional climate mitigation plan. Each jurisdiction has adopted the following regional greenhouse gas (GHG) [1] emission reduction targets:

- 45% reduction below 2015 levels by 2030, and
- 85% below 2015 levels by 2050.

A community's ability to take effective action on climate change depends on having information on GHG emissions. . An inventory enables communities to understand the relative importance of different sources and measure progress on achieving emission reduction targets. Consequently, developing a GHG inventory is a key component of effective climate mitigation strategies

The Thurston Climate Action Team (TCAT) prepared this report in order to provide updated[2] information on GHG emissions that will enable regional decision makers to make informed choices about measures to reduce the region's GHG footprint. TCAT compiled data about emission sources for the 2010 - 2018 time period and estimated GHG emissions for those years using internationally-accepted methods for preparing community emission inventories. Emission estimates for the 2015 – 2018 time period are presented in this report.

Key findings from TCAT's estimates of greenhouse gas emissions in 2018 include:

- The Thurston region's 2018 carbon footprint was 3,070,839 metric tons reported as carbon dioxide equivalents (MTCO2e). The built environment and transportation sectors were the two largest emission sectors and together contributed 92% of the Thurston region's overall carbon footprint in 2018. (See Figure ES-1).
- The three largest emission sources in 2018 were residential buildings (32%), passenger vehicles (27%) and commercial buildings (22%) (See Figure ES-2).
- Emissions in 2018 were about 7% higher than emissions during the baseline year (2015) that is being used to evaluate regional climate mitigation efforts (See Figure ES-3). Several factors contributed to the increase in estimated emissions: (1) increased population; (2) colder winter temperatures; (3) increased solid waste volumes.
- Per capita emissions in 2018 (10.9 MTCO2e/person) were about 2% higher than the per capita emissions in 2015 (See Figure ES-4).
- Emissions and per capita emissions in 2018 were about 3% and 4% lower, respectively, relative to 2017. This reversed the trend during the 2015 – 2017 period when emissions and per capita emissions increased by 10% and 6%, respectively.
- Achieving the Thurston region's climate goals will require annual emission reductions that are much larger than the annual reductions achieved between 2010 and 2018.

[1] Greenhouse gases (GHGs) are natural and industrial gases that trap heat and warm the Earth's surface.

[2] In August 2018, the Thurston Climate Action Team (TCAT) published a community-based-GHG emission inventory for calendar years 2010 through 2016 (TCAT 2018). The August 2018 document expanded on an earlier TCAT report published in 2014 (TCAT 2014).

Figure ES-1: Sectors of greenhouse gas emissions in Thurston Region in 2018 (% Contribution).

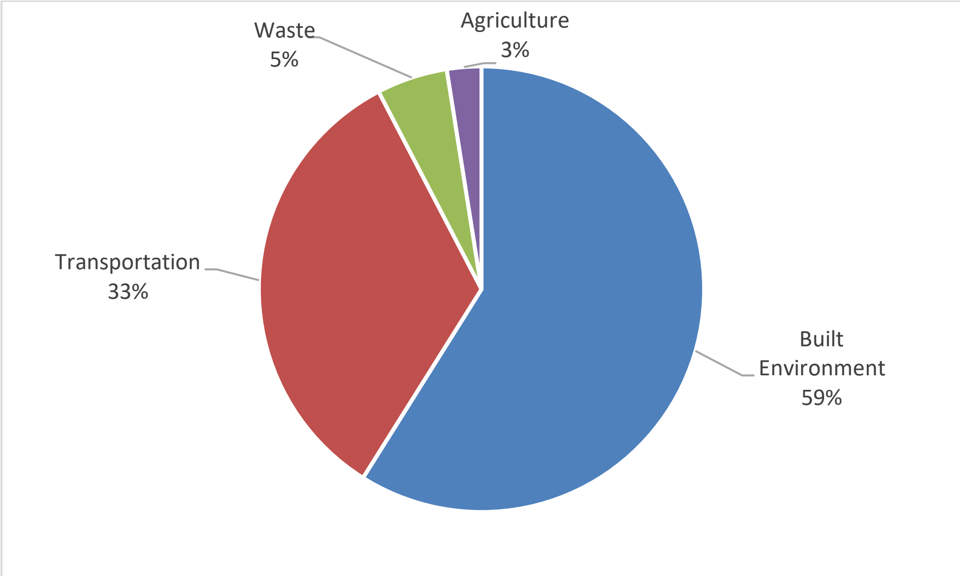


Figure ES–2: Sources of GHG Emissions in the Thurston Region in 2018 (% Contribution)

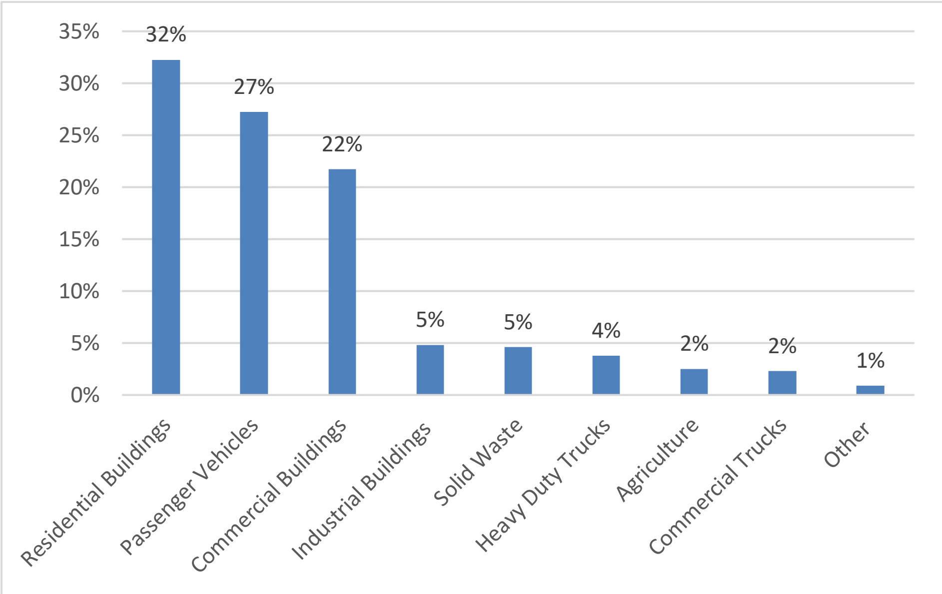


Figure ES-3. Thurston County greenhouse gas emissions (2015 emissions = 100%).

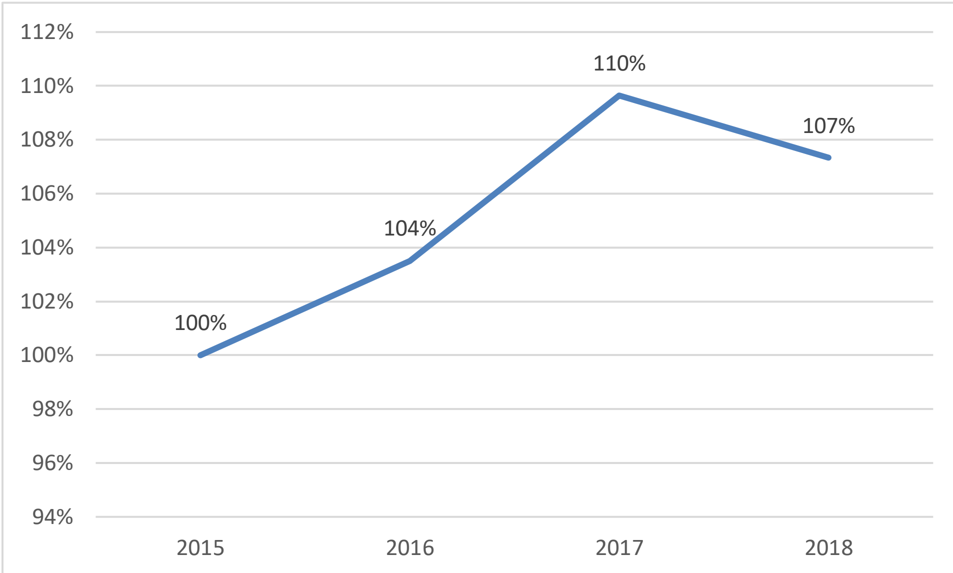
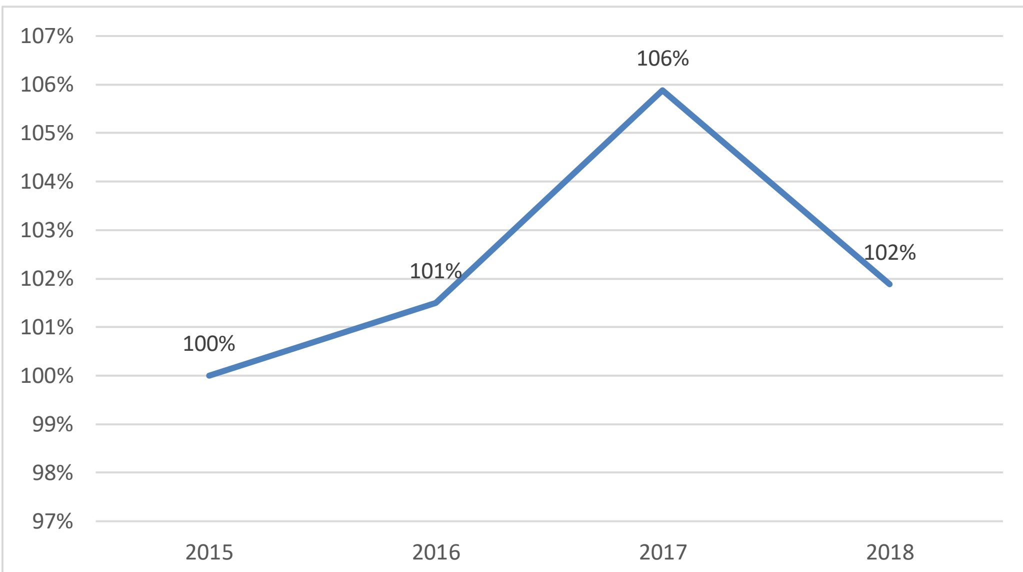


Figure ES-4. Thurston County per capita greenhouse gas emissions (2015 emissions = 100%).



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Acronyms

EIA	United States Energy Information Association
EPA	United States Environmental Protection Agency
CO_2e	Carbon dioxide equivalents
GHG	Greenhouse gas, limited to CO_2, CH_4, N_2O, and fugitive gases in this inventory
kWh	Kilowatt hours
LPG	Liquefied petroleum gas
$MTCO_2e$	Metric Tons of Carbon dioxide equivalents
MOVES	Motor Vehicle Emission Simulator model, a model developed by U.S. EPA to quantify emissions from mobile sources
NONROAD	A tool developed by U.S. EPA to quantify non-road mobile emissions
PSE	Puget Sound Energy
TCR	The Climate Registry
TCAT	Thurston Climate Action Team
TRPC	Thurston Regional Planning Council
USDA	United States Department of Agriculture
WARM	Waste Reduction Model, a model developed by EPA to quantify solid waste emissions
WSDOT	Washington Department of Transportation
VMT	Vehicle Miles Traveled

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Introduction

What is the purpose of this report?

Effective action on climate change requires information on GHG emissions and sources. An inventory enables communities to understand the relative importance of different sources and measure progress on achieving emission reduction targets. Consequently, a GHG inventory is a key component of a well-designed climate mitigation strategy.

The Thurston Climate Action Team (TCAT) prepared this report in order to provide updated information on GHG emissions in the Thurston region. The updated information will enable regional decision makers to make informed choices about measures to reduce the region's GHG footprint. TCAT compiled data about emission sources for 2010 through 2018 and estimated GHG emissions for those years using internationally-accepted methods for preparing community emission inventories. Emission estimates for the 2015 – 2018 time period are presented in this report.

What are the regional GHG emission reduction goals?

Lacey, Olympia, Tumwater and Thurston County are preparing a regional climate mitigation plan. Each jurisdiction has adopted the following regional emission reduction targets (TRPC, 2020f):

- 45% reduction below 2015 levels by 2030, and
- 85% below 2015 levels by 2050.

The local governments selected calendar year 2015 as the baseline year for measuring progress on climate mitigation efforts. While calendar year 1990 has traditionally been used to measure progress on emission reduction efforts, local officials concluded that the local information on 2015 emission levels is more reliable than the local emission information available for calendar year 1990.

What data and methods were used to prepare this inventory?

This report provides a geographic-plus inventory that estimates GHG emissions associated with activities occurring within the Thurston region "plus" emissions associated with producing the electricity used in the community, even though that electricity is generated outside the Thurston region. This inventory also includes emissions associated with the transportation and disposal of solid waste generated by residents and businesses even though local solid waste is currently disposed at a landfill located outside Thurston County.

TCAT prepared this inventory in accordance with the requirements and procedures established by the U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions (US Protocol) prepared by the International Council of Local Environmental Initiatives (ICLEI 2013a). This protocol was supplemented by the more recent 'Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories' prepared by the World Resource Institute (WRI), C40 Cities and ICLEI (WRI et al, 2014). The US and Global protocols provide internationally-accepted methods that enable comparisons with emission inventories prepared by other cities and counties.

The US and Global Protocols establish a four-step process for estimating GHG emissions:

1. Identify relevant source categories: This inventory quantifies emissions that result from community activities, regardless of whether those emissions occur within the county boundaries. For example, emissions from building energy include emissions from the combustion of heating fuels (natural gas, wood, fuel oil, and LPG) and emissions associated with the electricity used in the county. Fuel combustion emissions occur within the county, while the emissions associated with generating the electricity used in Thurston County occur outside the county.

2. Obtain activity data for source categories. The US and Global Protocols use information on electricity and natural gas use, vehicle miles traveled and other activity measures to develop GHG emission estimates. TCAT worked with a wide variety of organizations and individuals to obtain the activity data used to prepare emission estimates. In particular, the Thurston Regional Planning Council (TRPC) compiles a wide range of data that they obtain from other organizations that were used to estimate emissions. For example, TRPC obtains annual information on electricity and natural gas consumption in Thurston County from Puget Sound Energy.

3. Identify appropriate emission factors. The US and Global Protocols provide standard emission factors for converting activity data into GHG emission estimates. TCAT supplemented the default emission factors with information from (1) the Puget Sound Energy annual emission inventory reports, (2) the United States GHG inventory reports, (3) waste composition information from Thurston County Solid Waste and (4) energy use and fuel efficiency information compiled by US Energy Information Administration (EIA) and Department of Transportation (USDOT).

4. Calculate GHG emissions. TCAT used the web-based ClearPath Community-Scale Emissions Management Software (ICLEI, 2019) to calculate GHG emissions. Emissions of individual GHGs were converted to metric tons of carbon dioxide equivalents[3] (MTCO2e) using current global warming potential (GWP) values.[4]

How do the methods used to prepare this report differ from those used to prepare the August 2018 report?

While TCAT generally used the same internationally accepted methods to prepare this report and the report completed in August 2018, there are some important differences in individual methods, data sources and assumptions.

1. Clearpath Software: TCAT used the updated version of the web-based ClearPath Community-Scale Emissions Management Software (ICLEI, 2019) to estimate GHG emissions. Most of the calculation methods were not significantly changed in the updated software, but changes to the solid waste module resulted in much higher emission estimates relative to the earlier software. TCAT also used the updated software to recalculate emission estimates for earlier years (2010 – 2017) when preparing this report.

2. Sector Groupings. TCAT revised the general sector groupings in order to integrate new emission sources in a way that is consistent with the general categories specified in the Global Protocol for Community Scale Greenhouse Gas Emission Inventories (WRI et al. 2014). The four source groupings used in this report are:
    - **Built Environment**[5] includes residential, commercial and industrial buildings and outdoor lighting;
    - **Transportation** includes on-road vehicles (passenger vehicles, commercial trucks and heavy-duty trucks) and certain off-road vehicles;
    - **Waste** includes solid waste management, composting, wastewater treatment and on-site septic systems;

[3] In this report, GHG emissions are expressed in terms of metric tons of carbon dioxide equivalent or "MTCO2e". The unit "CO2e" represents an amount of a GHG whose impact has been standardized to that of one unit mass of carbon dioxide (CO2), based on the global warming potential (GWP) of the gas.

[4] The Global Warming Potential (GWP) published by the International Panel on Climate Change (IPCC) in 2013 were used to prepare this report.

[5] The Global Protocol (WRI et al, 2014) and the Clearpath Software (ICLEI, 2019) use the term "Stationary Energy for this category, but ICLEI USA continued to use "Built Environment" in the 2017 King County Emission inventory.

- **Agriculture** includes agricultural livestock (enteric fermentation and manure management) and agricultural soil management.

3. Emission Sources: TCAT has included several source categories in this report that were not included in previous reports (TCAT, 2014 and 2018). TCAT added these sources in response to review comments and an examination of inventories prepared by other communities. Table 1 below summarizes GHG source categories that were included in the August 2018 report and the sources included in this inventory update. TCAT prepared emission estimates for the additional sources for calendar years 2010 through 2018 using consistent methods and data sources.

Table 1. Comparison of Activities Included in the TCAT 2018 and the 2020 Update Reports.

	2018 Report	2020 Update
Built Environment		
Residential buildings (electricity, natural gas, fuel oil, LPG and wood)	✓	✓
Commercial buildings (electricity and natural gas)	✓	✓
Industrial buildings (electricity and natural gas)	✓	✓
Outdoor lighting (electricity)	✓	✓
Transportation		
On-road vehicles	✓	✓
Miscellaneous off-road vehicles and equipment		✓
Waste		
Methane from landfills	✓	✓
Solid waste processing	✓	✓
Solid waste transport	✓	✓
Composting		✓
LOTT – Digester gas	✓	✓
LOTT – Methanol use	✓	✓
LOTT - Effluent		✓
LOTT - Process		✓
Septic Tanks		✓
Agriculture		
Livestock (enteric fermentation)	✓	✓
Livestock (manure management)		✓
Agricultural soils management		✓

4. Vehicle Miles Traveled: TCAT used annual VMT estimates prepared by the TRPC to prepare emission estimates for on-road vehicles (passenger vehicles, commercial trucks and heavy-duty trucks). The August 2018 report was prepared using VMT estimates that included mileage for vehicles traveling through the county on I-5 or other routes (through-traffic).

   When preparing this report, TCAT used adjusted VMT values (TRPC, 2020e) that exclude vehicle miles attributable to through-traffic because local emission reduction strategies are unlikely to have meaningful impact on through-traffic emissions. Table 1 illustrates that excluding through-traffic from the VMT resulted in a 12% reduction in the overall VMT used to estimate GHG emissions with higher percentage reductions for heavy-duty trucks, light trucks and medium trucks.[6] TCAT also used the adjusted VMT values to recalculate on-road transportation emission estimates for the 2010 – 2017 period.

Table 2: Example of Adjustments to VMT Estimates (2018 Calendar Year)

	Total VMT	Through Traffic	Adjusted VMT	% Difference
Passenger Vehicles	2,321,331,650	223,364,144	2,097,967,506	-10%
Light Trucks	42,030,606	10,683,948	31,346,657	-25%
Medium Trucks	41,946,460	7,788,662	34,157,798	-19%
Heavy Duty Trucks	124,118,143	53,836,718	70,281,426	-43%
All Vehicles	**2,529,426,859**	**295,673,472**	**2,233,753,387**	**-12%**

Organization of the Report

The remainder of this report is organized into the following sections:

- Overview of the 2018 Thurston County Inventory: This chapter summarizes emission estimates and trends.
- Results of the 2018 Thurston County Inventory: This chapter provides information on the following sectors:
  - **Built Environment**: This section describes emissions from residential, commercial and industrial buildings and outdoor lighting;
  - **Transportation**: This section describes emissions from on-road vehicles (passenger vehicles, commercial trucks, and heavy-duty vehicles) and off-road vehicles and equipment;
  - **Waste**: This section describes emissions from solid waste management, composting, wastewater treatment plants and on-site septic systems; and
  - **Agriculture**: This section describes emissions from agricultural livestock (enteric fermentation and manure management), and agricultural soil management.
- Other Sources not Included in This Report. This chapter summarizes information on other emission sources and consumption-based emission estimates.
- Conclusion: This chapter summarizes the overall findings and provides a brief discussion on implications for future progress and action planning.
- References: This section provides citations for the documents and information used to prepare this report.

6 Estimated emissions associated with through-traffic in 2018 were about 200,000 MTCO2e.

Overview of the 2018 Thurston County Inventory

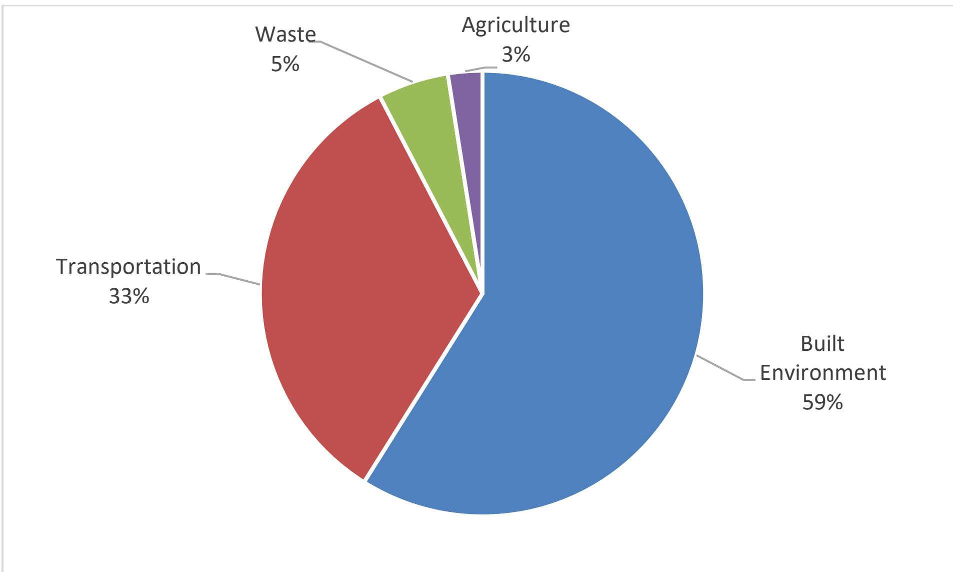
This section summarizes (1) the Thurston County's 2018 GHG emission inventory results, (2) how the County's emissions changed between 2015 and 2018 and (3) how the County's emissions compare with emissions in other areas. More detailed information on emissions from individual sectors is provided in the next chapter.

What was the Thurston region's carbon footprint in 2018?

The Thurston region's 2018 carbon footprint was 3,070,839 metric tons reported as carbon dioxide equivalents (MTCO2e). Per capita emissions in 2018 were 10.9 MTCO2e/person.

The built environment and transportation sectors were the two largest emission sectors and together contributed 92% of the Thurston region's carbon footprint in 2018. (See Figure 1 and Table 2).

Figure 1. Sectors of GHG emissions in the Thurston Region in 2018 (% Contribution).



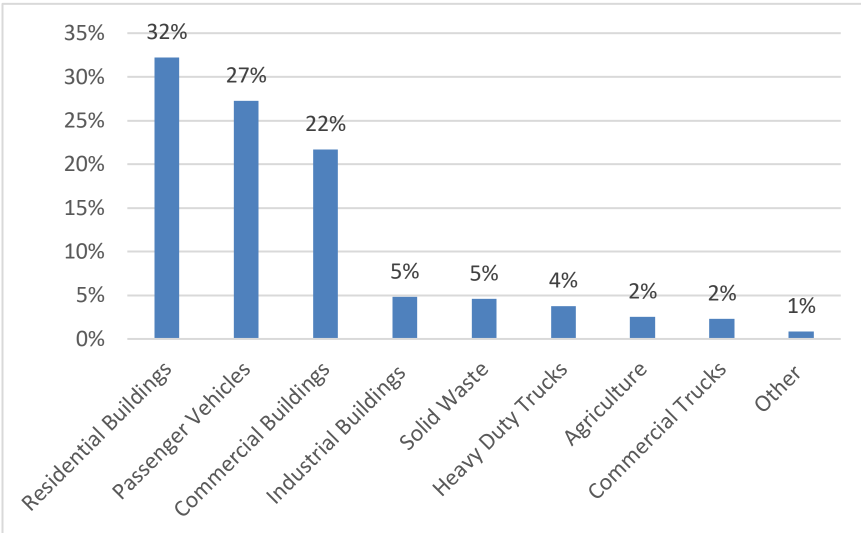
Activities taking place in the region can generate GHG emissions both inside and outside the region's boundaries. The Global Protocol includes three categories or "scopes" for classifying emissions.

- ***Scope 1*** emissions represented 48% of total emissions in 2018. Scope 1 emissions are GHG emissions from sources located within the county. The US and Global Protocols identify a wide range of Scope 1 emission sources. Many of the Scope 1 emissions in those two documents are included in this report. Scope 1 emissions in this report include: (1) natural gas and other fuels burned in homes and businesses, (2) on-road and off-road vehicles, (3) agricultural livestock, agricultural soil management, and (4) wastewater treatment facilities, septic systems and composting.
- ***Scope 2*** emissions represented 39% of total emissions in 2018. Scope 2 emissions are GHG emissions from the Thurston region's use of grid-supplied electricity even though the electricity is generated outside the region.
- ***Scope 3*** emissions represented 13% of total emissions in 2018. Scope 3 emissions include GHG emissions that occur outside the region as a result of activities that occur within the region. The US and Global Protocols identify a wide range of Scope 3 emission sources for cities. Many of the Scope 3 activities identified in those two

documents are included in this report. Scope 3 emissions included in this report are emissions associated with (1) the disposal of solid waste at the Roosevelt Landfill in eastern Washington, (2) electricity transmission and distribution losses and (3) upstream emissions associated with producing natural gas and other home heating fuels and emissions associated with producing the coal and natural gas used to generate electricity. [7]

The three largest emission sources in 2018 were residential buildings (32%), passenger vehicles (27%) and commercial buildings (22%) (See Figure 2 below and Table 4 at the end of this chapter).

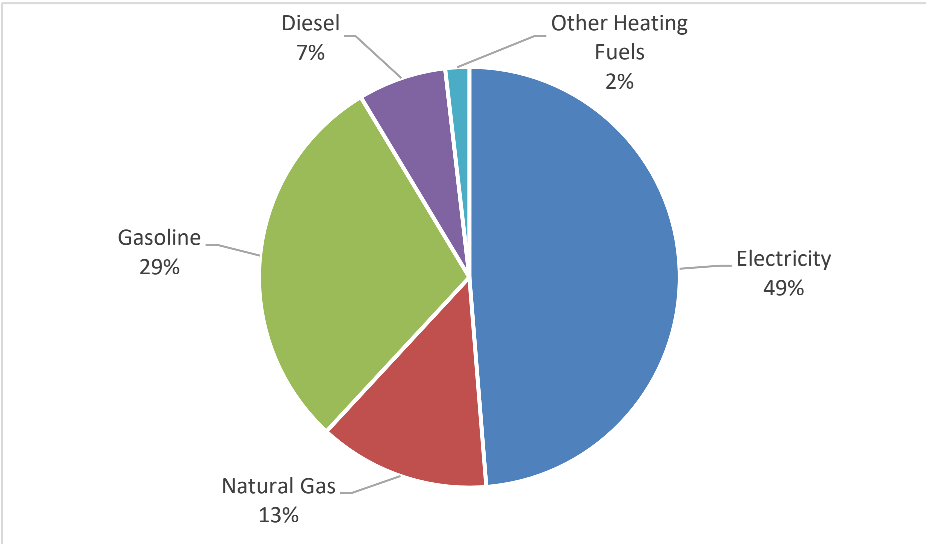
Figure 2. Sources of GHG emissions in the Thurston Region in 2018 (% Contribution).



[7] Scope 3 emissions share some characteristics with consumption-based emissions. For example, an estimate of the consumption-based emissions associated with on-road vehicles includes emissions associated with producing, driving and disposing vehicles. The emissions associated with producing and disposing vehicles would generally be considered Scope 3 activities since they occur outside the county. Emissions associated with driving vehicles within Thurston County would be classified as Scope 1 activities. TCAT developed preliminary estimates for Thurston County consumption-based emissions for calendar year 2015. These estimates are presented later in this document for information purposes-only.

Energy-related activities were the primary sources of GHG emissions in Thurston County and accounted for about 92% of the County's GHG emissions in 2018. The generation, distribution and use of electricity was the largest contributor (48%) to energy-related emissions in 2018 (Figure 3).

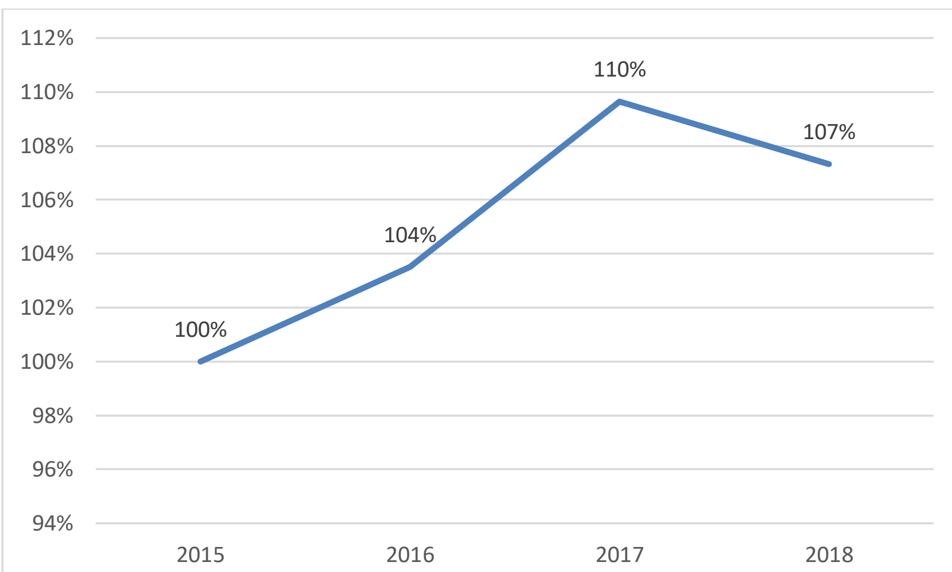
Figure 3: Percentage of Energy-Related Emissions in 2018



How did greenhouse gas emissions change between 2015 and 2018?

Emissions in 2018 were about 7% higher than emissions during the baseline year (2015) being used to evaluate regional climate mitigation efforts (See Figure 4). Several factors contributed to the increase in estimated emissions: (1) increased population; (2) colder winter temperatures; (3) increased solid waste volumes.

Figure 4. Thurston County greenhouse gas emissions (2015 emissions = 100%).



Per capita emissions in 2018 were 10.9 MTCO2e/person. Per capita emissions in 2018 were slightly above (about 2%) the per capita emissions in 2015 (See Figure 5).

Figure 5. Thurston County per capita greenhouse gas emissions (2015 emissions = 100%).

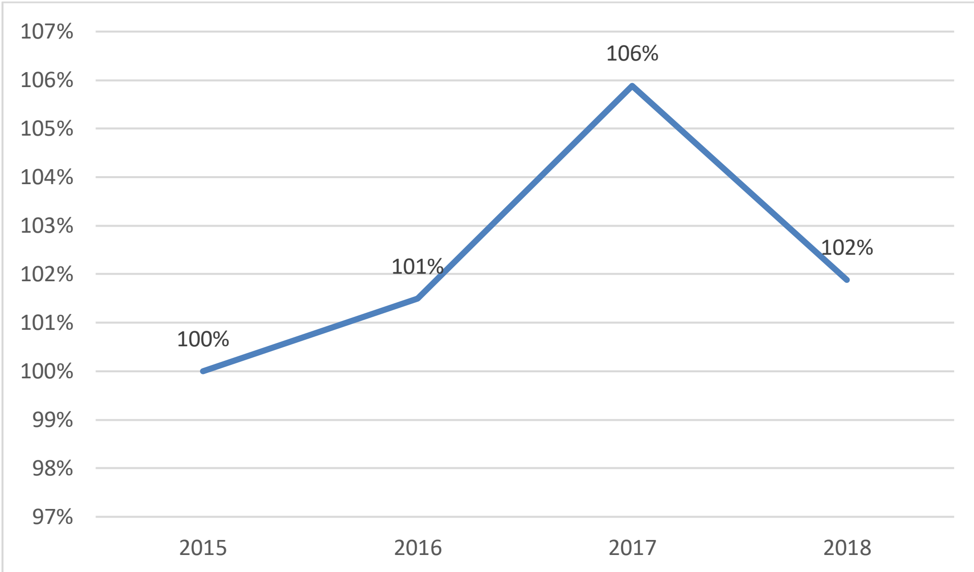


Table 3 summarizes emission changes for various source categories between 2015 and 2018:

- Emissions from most source categories increased between 2015 and 2018. Emission increases range from about 1% to almost 100%.
- The most notable exception was outdoor lighting (included in the "Other" source category in Table 3) where emissions fell by 34% between 2015 and 2018.

Table 3: Change in Emissions Between 2015 and 2018.

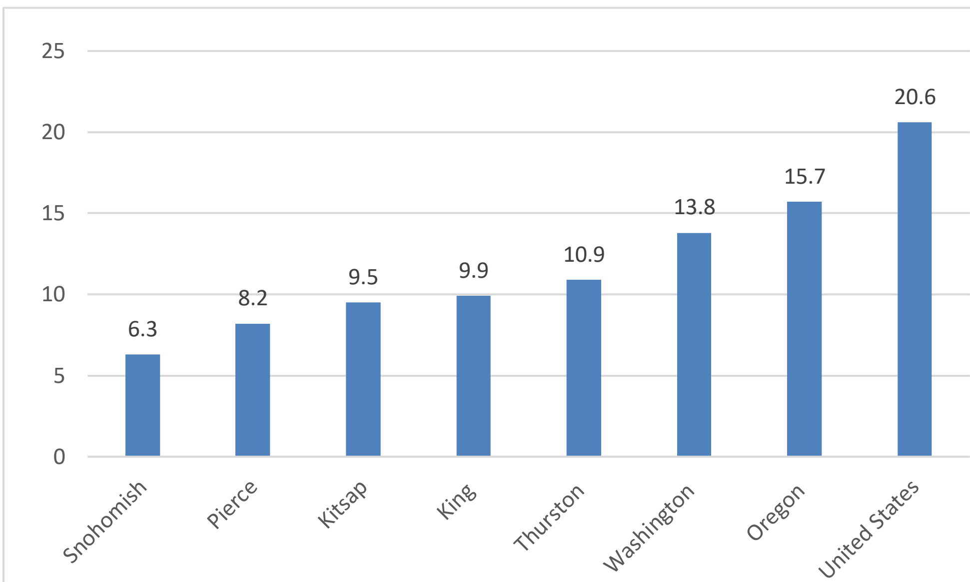
	2015	2018	Change	% Change
Residential Buildings	932,260	990,403	58,143	6.2%
Passenger Vehicles	816,656	835,984	19,328	2.4%
Commercial Buildings	632,719	666,361	33,642	5.3%
Industrial Buildings	74,247	147,582	73,334	98.8%
Solid Waste	120,446	141,160	20,714	17.2%
Heavy Duty Trucks	113,088	115,503	2,415	2.1%
Agriculture	76,904	76,762	-141	-0.2%
Commercial Trucks	69,400	69,967	567	0.8%
Other	29,500	27,117	-2,383	-8.1%
TOTAL	2,865,220	3,070,839	205,619	7.2%

How did GHG Emissions in Thurston County Compare with Emissions in Other Areas in 2015[8]?

The Puget Sound Clean Air Agency (PSCAA) published a GHG inventory for the four counties within their jurisdiction (King, Kitsap, Pierce and Snohomish counties) for calendar year 2015 (PSCAA, 2018). Per capita emissions in Thurston County are generally higher than the per capita emission estimates reported for these four counties (See Figure 5). In general, these counties have higher population densities and more multi-family homes that tend to produce lower per capita building and transportation emissions. These counties also have cleaner sources of electricity (lower emissions of greenhouse gases per kilowatt-hour) where a larger share of electricity is produced from hydropower and wind.

While the 2015 per capita GHG emissions in the County were higher than the four PSCAA counties, the County's per capita emissions were below the 2015 per capita emissions for Washington (Ecology, 2019), Oregon (DEQ, 2019) and the United States (EPA, 2020a) (See Figure 5).[9]

Figure 6: Comparison of 2015 Per Capita Emissions (MTCO2e/resident)

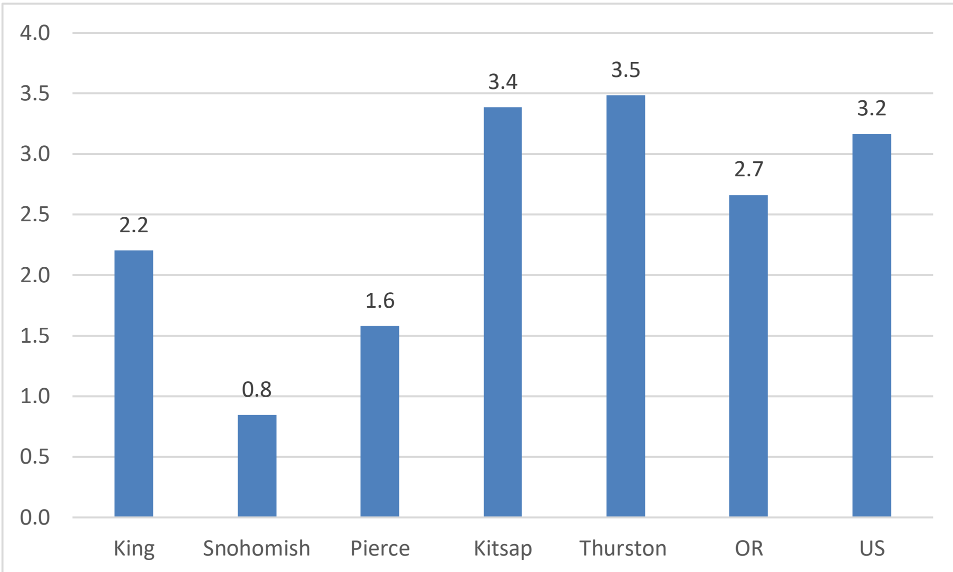


Comparisons based on total emissions can be misleading since there are variations in the range of sources included in different inventories. To address this issue, TCAT compared per capita emissions for individual sectors (Figures 7 and 8). Thurston County residential emissions are higher than other areas which is largely related to the higher carbon intensity associated with the electricity used in the County relative to the electricity in other areas. Puget Sound Energy is continuing efforts to use more renewable energy sources to produce electricity and, over the next decade, this should lower the carbon intensity of electricity used in Thurston County.

8 The year 2015 was selected because (1) PSCAA published a GHG inventory for the four counties within their jurisdiction for calendar year 2015 and (2) 2015 is the latest year where emission estimates are available for Washington, Oregon and the United States.

9 The state and federal emission estimates were developed using slightly different methodologies than the methods used to prepare the Thurston region estimates.

Figure 7: Comparison of 2015 Per Capita Residential Building Emissions (MTCO2e/resident)



On-road transportation emissions followed a pattern similar to total emissions. The 2015 on-road per capita GHG emissions in Thurston County were higher than the four PSCAA counties, but lower than the 2015 per capita on-road transportation emissions in Washington, Oregon and the United States.

Figure 8: Comparison of 2015 Per Capita On-Road Vehicle Emissions (MTCO2e/resident)

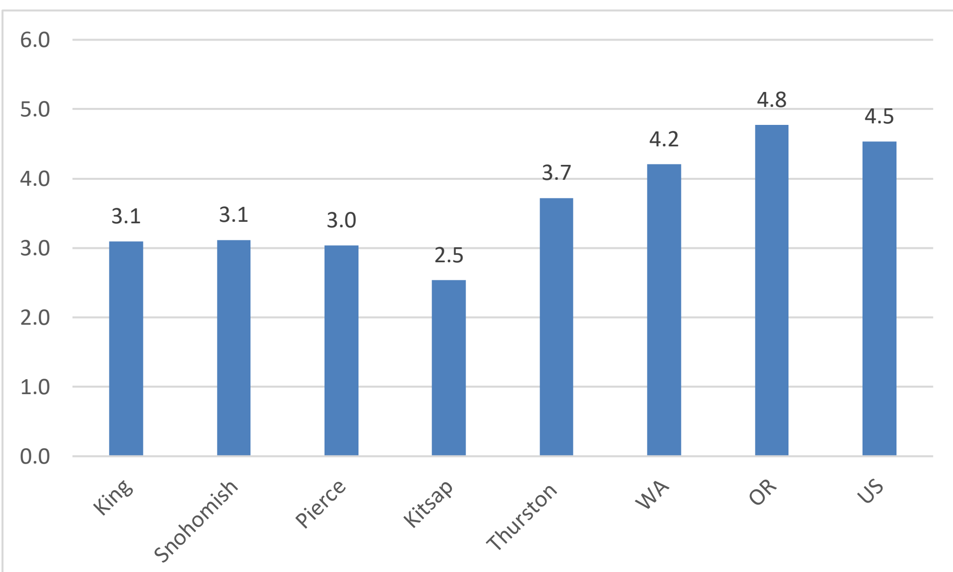


Table 4 presents the information used to prepare the charts and figure presented in this chapter and discussed in greater detail in subsequent chapters on individual emission sectors.

Table 4: GHG Emissions by Sector (MTCO2e)

	2015	2018	% Change
Built Environment	1,647,372	1,809,710	9.9%
Residential	932,260	990,403	6.2%
Electricity	702,178	714,260	1.7%
Natural Gas	187,693	223,877	19.3%
Other Heating Fuels	42,390	52,266	23.3%
Commercial	632,719	666,361	5.3%
Electricity	537,234	549,079	2.2%
Natural Gas	95,485	117,283	22.8%
Industrial	74,247	147,582	98.8%
Electricity	67,627	114,399	69.2%
Natural Gas	6,620	33,182	401.2%
Outdoor Lighting	8,145	5,365	-34.1%
Electricity	8,145	5,365	-34.1%
Transportation	**999,929**	**1,026,303**	**2.2%**
On-road vehicles	**995,144**	**1,021,454**	**2.2%**
Passenger Vehicles	816,656	835,984	2.4%
Commercial Trucks	69,400	69,967	0.8%
Heavy Duty Trucks	113,088	115,503	2.1%
Off-road vehicles	**4,805**	**4,849**	**0.9%**
Waste	**136,996**	**158,063**	**15.4%**
Solid waste	**120,446**	**141,160**	**17.2%**
Wastewater	**16,550**	**16,903**	**2.1%**
Agriculture	**76,904**	**76,762**	**-0.2%**
Enteric Fermentation	**36,879**	**36,480**	**-1.1%**
Manure Management	**38,540**	**38,573**	**0.1%**
Agricultural Soil Management	**1,485**	**1,709**	**15.1%**
TOTAL Emissions	**2,865,220**	**3,070,839**	**7.2%**

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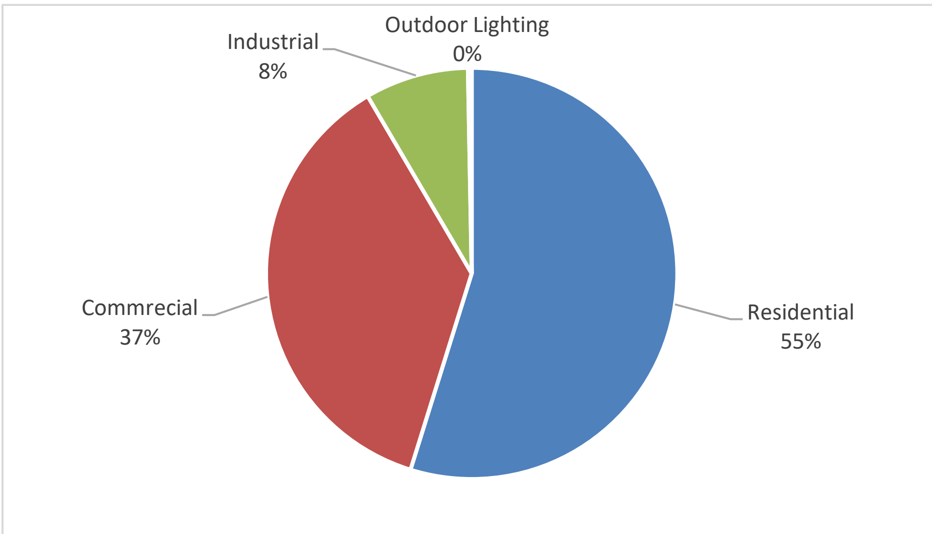
Results of the 2018 Thurston County Inventory

Built Environment

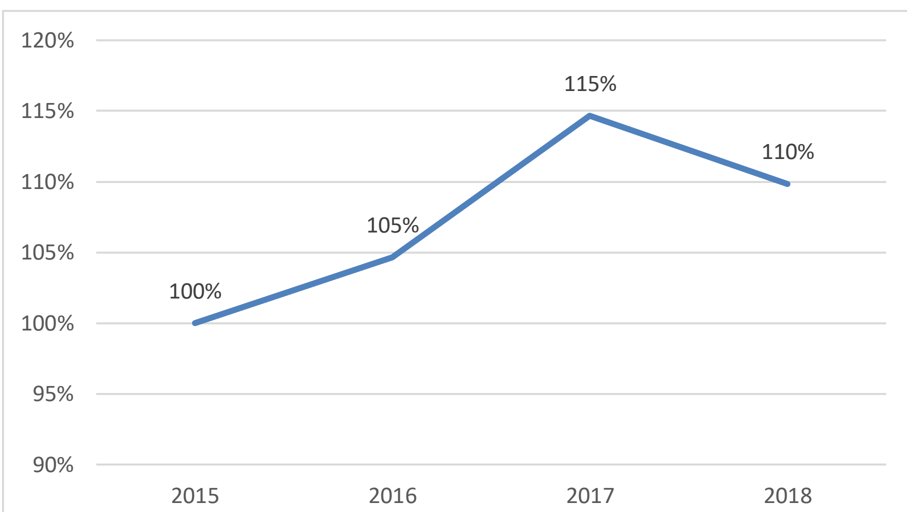
Stationary energy used for residential, commercial and industrial buildings and outdoor lighting accounted for the largest portion of the Thurston region's carbon footprint (59%) with 1,809,710 MTCO2e in 2018. Residential buildings were responsible for 55% of built environment emissions (32% of total emissions).

Figure 9: Distribution of Built Environment emissions in 2018 (% of Built Environment emissions)



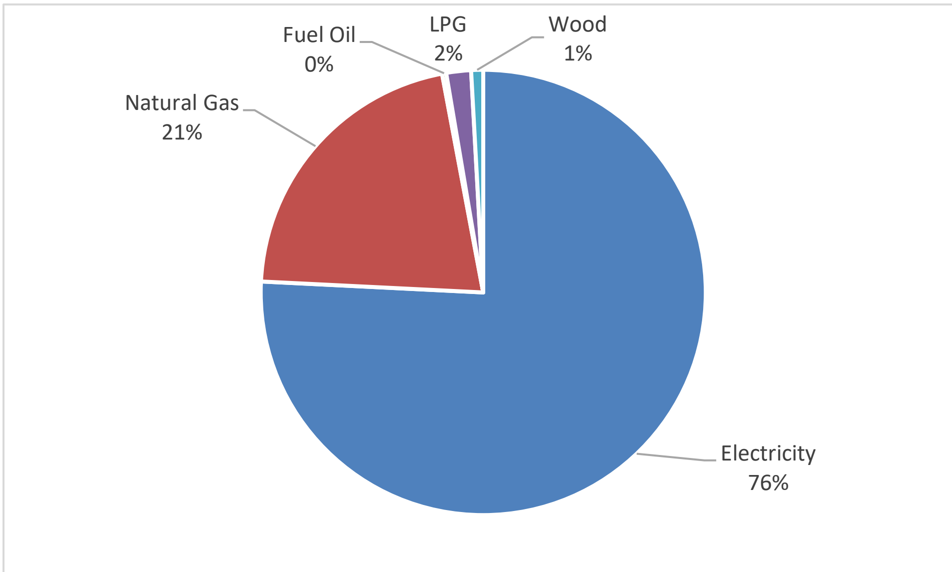
Total built environment emissions in 2018 were 10% higher than emissions in 2015 (See Figure 10). Per-capita built environment emissions were about 4% higher than per-capita emissions in 2015.

Figure 10: Trend in Built Environment Emissions (expressed as % of 2015 emissions)



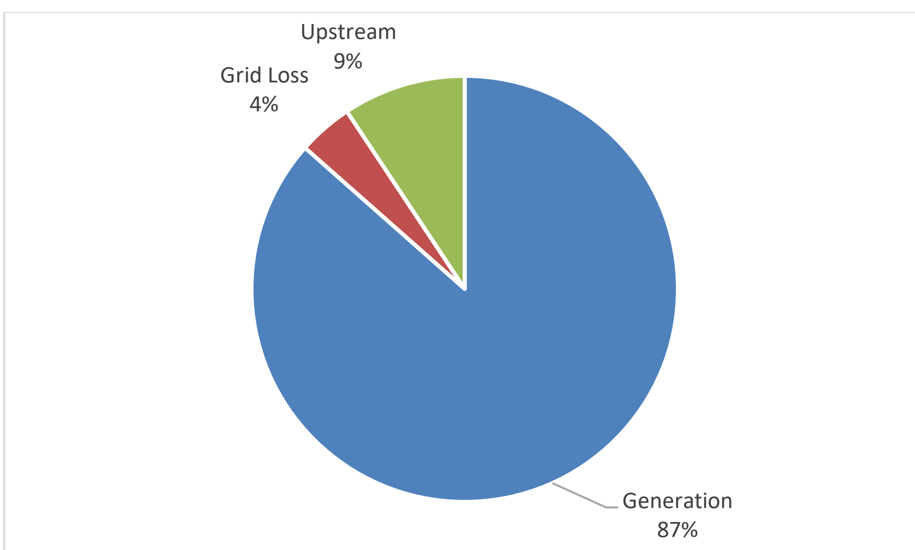
In 2018, the use of electricity accounted for the largest portion of built environment emissions (about 76%), followed by natural gas (about 21%). The use of other residential heating fuels (fuel oil, LPG and wood) represented a small part (almost 3%) of built environment emissions in 2018 (See Figure 11)

Figure 11: Distribution of Energy Sources Associated with Built Environment Emissions



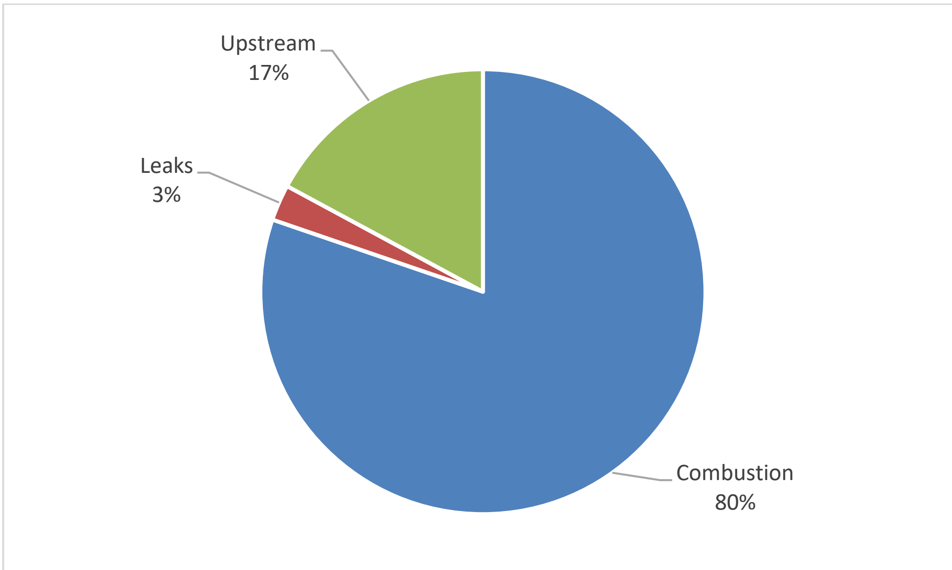
Emissions from electricity include three components: (1) emissions associated with the generation of the electricity used by Thurston residents and businesses, (2) emissions associated with electricity losses during transmission and distribution; and (3) emissions that occur during the production of the fuels used to generate electricity (upstream emissions). As shown in Figure 12, emissions associated with electricity generation are the largest portion of electricity emissions (87%).

Figure 12: Sources of Emissions Associated With Electricity Production, Transmission and Use (2018)



Natural gas emissions also include three components: (1) emissions from direct combustion; (2) emissions due to leaks during the transmission and distribution of natural gas; and (3) upstream emissions that occur during the production of natural gas. As shown in Figure 13, emissions resulting from the direct combustion of natural gas represents 80% of natural gas emissions in 2018.

Figure 13: Sources of Emissions Associated with Natural Gas Combustion, Leaks and Production (2018)



The Thurston region's electricity is also connected to the regional grid. As recommended in the U.S. Community Protocol, TCAT compared the utility-specific emission estimates with the regional grid. In general, the average emission intensity for the Northwest Power Pool (NWPP) regional grid is about 40% lower than the PSE emission intensity. [10] Table 5 illustrates that the emissions associated with the electricity provided by PSE to Thurston County customers is higher (about 500,000 MTCO2e) than the emissions that would occur if PSE's mix of fuel sources matched that of the full NWPP regional grid. In other words, the mix of fuel sources used by PSE to generate electricity contains a higher percentage of coal and natural gas than the average mix of fuel sources used throughout the NWPP region.

Table 5: Comparison of 2018 GHG Emissions From Electricity Generated by Puget Sound Energy and the NWPP Regional Grid (MTCO2e).

	Puget Sound Energy	NWPP Regional Grid
Generation	1,196,752	736,122
Transmission/Distribution Losses	57,444	35,334
Upstream	128,907	101,175
Total Electricity	**1,383,102**	**872,631**

[10] in the most recent eGRID publication (EPA, 2020c), the emission intensity for the NWPP regional grid is 643 lbs CO2e/MWh. This is about 40% lower than the PSE emission intensity for electricity provided to PSE customers in 2018 (1030 lbs CO2e/MWh) (PSE, 2019).

Residential Buildings

Residential buildings were the largest source of built environment emissions in 2018 with 990,403 MTCO2e (representing 55% of built environment emissions and 32% of total emissions). Electricity was the largest contributor to residential building emissions (72%) followed by natural gas (23%) and other heating fuels (5%)

Emissions from residential buildings in 2018 were about 6% higher than emissions in 2015. Per-capita emissions were about 1% higher. Factors contributing to the increase in emissions from residential buildings include:

- Growth: The county's population increased from 267,400 to 281,700 people between 2015 and 2018 (5.3% growth). Energy consumption for electricity (Kwh/customer) remained essentially unchanged. Energy consumption for natural gas (therms/customer) increased by 13%.
- Weather-Related Demand. 2018 was generally colder than 2015 with about 11% more Heating Degree Days.[11]

Table 6: Emissions from Residential Buildings (MTCO2e).

	2015	2018	% Change
Electricity	702,178	714,260	1.7%
Natural Gas	187,693	223,877	19.3%
Other Heating Fuels	42,390	52,266	23.3%
Residential	**932,260**	**990,403**	**6.2%**

Commercial Buildings

Commercial buildings were the second largest source of built environment emissions in 2018 with 666,361 MTCO2e (representing 37% of built environment emissions and 22% of total emissions). Emissions associated with the use of electricity represented about 82% of emissions from commercial buildings.

Emissions from commercial buildings in 2018 were about 5% higher than emissions in 2015. The factors contributing to the increase in emissions from commercial buildings are likely similar to those for residential buildings, but are probably more variable given the variability in the numbers, types and sizes of commercial buildings.[12]

[11] Heating degree day (HDD) is a measurement designed to quantify the demand for energy to heat a building. This measure reflects the assumption that when the outside temperature is 65°F, people don't need to heat their homes in order to be comfortable. For example, a temperature of 60 degrees would represent 5 HDDs. Building heating energy demands are considered to be proportional to heating degree days. Conversely, building cooling needs (fans, air conditioning and dehumidifiers) are considered to be proportional to cooling degree days (CDD). Building cooling needs are expected to increase as average temperatures increase and a higher % of homes are built with air conditioning.

[12] While the number of commercial customers increased for both electricity (4.5%) and natural gas (4.1%) between 2015 and 2018, energy consumption per customer also increased for both energy sources (electricity (1%) and natural gas (18%)).

Table 7: Emissions from Commercial Buildings (MTCO2e).

	2015	2018	% Change
Electricity	537,234	549,079	2.2%
Natural Gas	95,485	117,283	22.8%
Commercial	**632,719**	**666,361**	**5.3%**

Industrial Buildings

Industrial buildings were the third largest source of built environment emissions in 2018 with 147,582 MTCO2e (representing 8% of built environment emissions and about 5% of total emissions). Emissions associated with the use of electricity represented about 77% of emissions from commercial buildings.

Emissions from industrial buildings in 2018 were almost 100% higher than 2015 emissions. Emissions associated with electricity and natural gas increased by about 70% and 400%, respectively.

Table 8: Emissions from Industrial Buildings (MTCO2e).

	2015	2018	% Change
Total Electricity	67,627	114,399	69.2%
Total Natural Gas	6,620	33,182	401.2%
Industrial	74,247	147,582	98.8%

Industrial emission estimates are limited to emissions associated with the use of electricity and natural gas at industrial buildings in Thurston County (as reported by Puget Sound Energy). These estimates do not include any process emissions released by local industrial facilities. Thurston County has no industrial process facilities that are large enough to be subject to greenhouse gas reporting requirements under state and federal GHG reporting rules.

Outdoor Lighting

Outdoor lighting accounted for a very small portion (0.4%) of stationary energy emissions in 2018 (5,365 MTCO2e), but represents one of the bright spots in emission reduction efforts.

Emissions from outdoor lighting in 2018 were 34% lower than emissions in 2015. Most of the observed decline can be explained by greater use of LED bulbs for outdoor lighting.

The decline in emissions occurred despite a 7% increase in the number of outdoor lighting customers between 2015 (612 customers) and 2018 (657 customers).

Until 2015, the increase in the number of outdoor lighting customers masked steady improvements in lighting efficiency. The energy efficiency impacts of using LED lighting for streetlights can be seen by tracking energy use for the universe of lights existing at the beginning of 2015. A recent review of electricity bills indicates that the electricity needed for the Tumwater streetlights in place at the beginning of 2015 fell by 45% between 2015 and 2019 as a result of the City's energy conservation measures.

Information Used to Estimate Built Environment Greenhouse Gas Emissions

TCAT estimated the emissions associated with the use of electricity by using information provided by Puget Sound Energy on the number of customers and annual amounts of electricity used for residential, commercial and industrial buildings and outdoor lighting (TRPC, 2020d) and the carbon intensity values published in the annual emission reports prepared by Puget Sound Energy (PSE, 2011 – 2019). Emissions associated with grid loss were estimated using information on the annual amounts of electricity used in the Thurston region and electricity transmission and distribution loss published by EPA (EPA, 2020b). Upstream emissions associated with electricity use were estimated using information on the annual amounts of electricity used in the Thurston region, fuel mix information compiled by the Washington Department of Commerce (WDOC, 2019) and the default emission factors for coal and natural gas production included in the Clearpath guidance for the built environment (ICLEI, 2013b).

TCAT estimated the emissions associated with the use of natural gas by using information provided by Puget Sound Energy on the number of customers and annual amounts of natural gas used for residential, commercial and industrial buildings (TRPC, 2020d). Emissions associated with leaks during natural gas distribution and upstream emissions were estimated using information on the annual amounts of natural gas and the default emission factors included in the Clearpath software model.

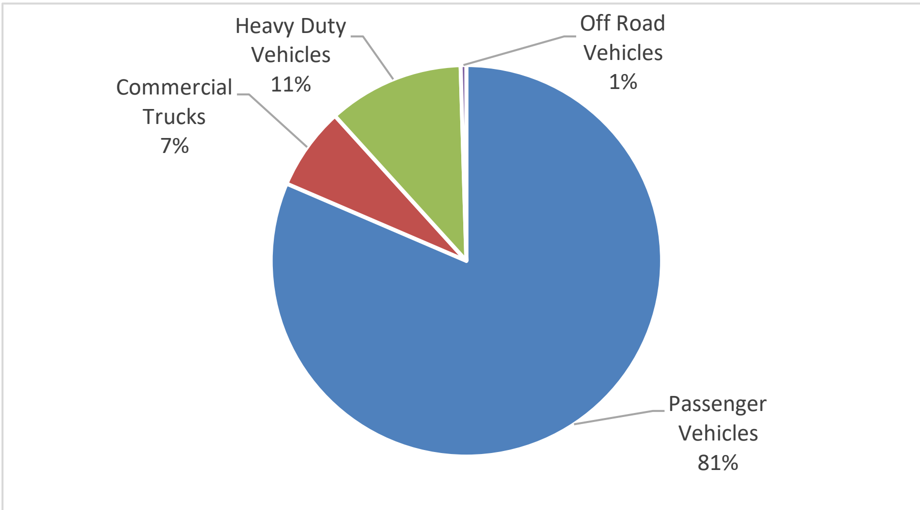
TCAT estimated the emissions associated with the use of other residential heating fuels (fuel oil, LPG and wood) by using residential energy consumption estimates for Washington State published by the United States Energy Information Administration (EIA, 2020) for years 2010 through 2017. Estimates for statewide energy consumption in 2018 for various fuel types were estimated using the data for the 2010 – 2017 time period and the EXCEL forecasting tools (ETS.Linear). Statewide energy consumption was used to estimate energy consumption for Thurston County by using information from the US Census Bureau on the number of households in Thurston County and Washington State using different types of heating fuels during the 2010 – 2018 time period (Census Bureau, 2020a). Upstream emissions were estimated using the default emission factors included in the Clearpath software model.

There are varying degrees of uncertainty associated with the methods, data and assumptions used to prepare GHG emission estimates for the built environment. In general, there is a low amount of uncertainty surrounding the estimates for natural gas and electricity use because of the high confidence in the information about electricity use, natural gas use and emission factors reported by Puget Sound Energy. This contrasts with the emission estimates for other residential heating fuels (i.e., fuel oil, LPG and wood) where there is a large amount of uncertainty because those estimates required numerous assumptions and extrapolations from statewide and national data.

Transportation

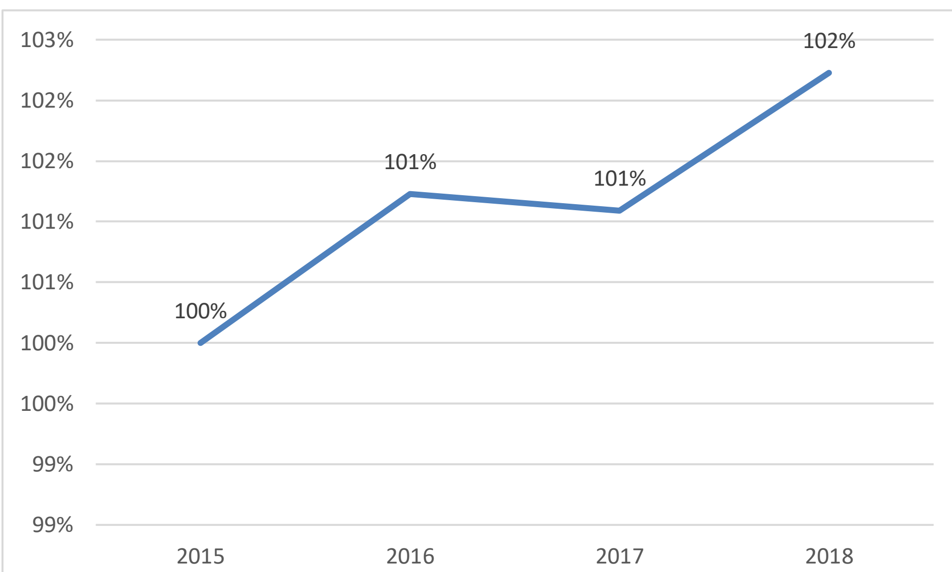
Transportation (passenger vehicles, commercial trucks, heavy duty-trucks and certain off-road vehicles) accounted for the second largest portion of Thurston County's carbon footprint (33%) with an estimated 1,026,303 MTCO2e in 2018. Passenger vehicles were the largest source of transportation emissions (81%).

Figure 14: Distribution of Transportation Emissions in 2018 (expressed as a percentage of total transportation emissions)



Transportation emissions in 2018 were about 3% higher than transportation emissions in 2015. Per-capita emissions were about 3% lower than per-capita emissions in 2015.

Figure 15: Trend in Transportation Emissions (expressed as % of 2015 emissions)



Passenger Vehicles

Passenger vehicles were the largest contributor to transportation emissions (81%) in 2018. About 98% of passenger vehicle emissions are associated with gasoline-powered vehicles. Emissions from passenger vehicles in 2018 were about 2% higher than emissions in 2015. Per-capita emissions were about 3% lower than per-capita emissions in 2015.

Table 9: Emissions from Passenger Vehicles (MTCO2e)

	2015	2018	% Change
PV - Gasoline	803,107	822,022	2.4%
PV - Diesel	13,549	13,962	3.0%
Passenger Vehicles	816,656	835,984	2.4%

Heavy Duty Vehicles

Heavy duty vehicles were the second largest contributor to transportation emissions (11%) in 2018. Almost 90% of heavy-duty vehicle emissions are associated with diesel-powered vehicles. Emissions from heavy duty vehicles in 2018 were about 6% higher than emissions in 2015. Per-capita emissions in 2018 were slightly higher (0.5%) than per-capita emissions in 2015.

Table 10: Emissions from Heavy Duty Vehicles (MTCO2e and MTCO2e/resident)

	2015	2018	% Change
HDT Vehicles - Gasoline	12,469	13,007	4.3%
HDT Vehicles – Diesel	100,619	102,496	1.9%
Heavy Duty Vehicles	**113,088**	**115,503**	**2.1%**

Commercial Trucks

Commercial trucks were the third largest contributor to transportation emissions (7%) in 2018. Emissions from commercial trucks in 2018 were about 1% higher than emissions in 2015. Per-capita emissions were about 4% lower than per-capita emissions in 2015.

Table 11: Emissions from Commercial Trucks (MTCO2e)

	2015	2018	% Change
Commercial Trucks	**69,400**	**69,967**	**0.8%**

Off-Road Vehicles and Equipment

Off-road vehicles and equipment were the smallest contributor to transportation emissions with 4,839 MTCO2e in 2018 (representing about 1% of transportation emissions and 0.3% of total emissions). Emissions from off-road vehicles in 2018 were about 1% higher than emissions in 2015. Per-capita emissions were about 4% lower than per-capita emissions in 2015.

Table 12: Emissions from Off-Road Vehicles (MTCO2e)

	2015	2018	% Change
Agriculture	214	205	-4%
Commercial	379	420	11%
Construction	2,605	2,511	-4%
Industrial	354	412	16%
Lawn/Garden	1,110	1,153	4%
Recreational	143	149	5%
Off Road TOTAL	**4,805**	**4,849**	**1%**

Information Used to Estimate Transportation Greenhouse Gas Emissions

TCAT estimated on-road transportation emissions by using the vehicle miles traveled (VMT) and vehicle fleet mix values (adjusted to exclude through-traffic) that were provided by the Thurston Regional Planning Council (TRPC, 2020e) and updated default emission factors published in the Clearpath model. The percentages of VMT for passenger vehicles, light-duty trucks and heavy-duty vehicles associated with gasoline and diesel-powered vehicles were estimated using national VMT distributions published by EPA (2020b).

Emissions from off-road vehicles and equipment for the 2015 – 2018 time period were developed using the EPA MOVEs software (EPA, 2018c). Estimates for the 2010 – 2014 time period were estimated using the 2015 – 2018 MOVES estimates and EPA estimates on Washington off-road emissions for the 2010 – 2017 time period (EPA, 2019b).

In general, there is a moderate amount of uncertainty surrounding on-road transportation emissions. EPA calculated a 95 percent confidence interval for on-road transportation emissions of -7% (lower bound) to +7% (upper bound). In other words, EPA calculated that there is a 2.5% chance that actual on-road transportation emissions are more than 7% lower than EPA's estimates and that there is a 2.5% chance that actual emissions are more than 7% higher than EPA's estimates. There are additional uncertainties associated with extrapolating the national data (such as fuel efficiency) to the Thurston region. It is unclear whether use of national data will over- or under-estimate the Thurston region's emissions.

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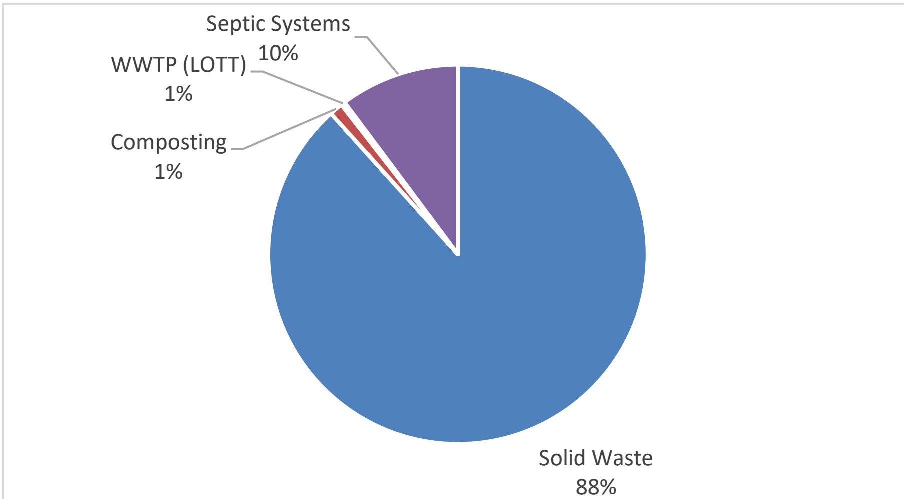
Waste

Emissions from solid waste, composting, wastewater treatment and septic tanks represented about 5% of the Thurston region's carbon footprint with an estimated 158,063 MTCO2e in 2018 (0.57 MTCO2e/resident). About 88% of waste-related emissions in 2018 were associated with managing the solid waste generated by Thurston County residents, businesses and governments.

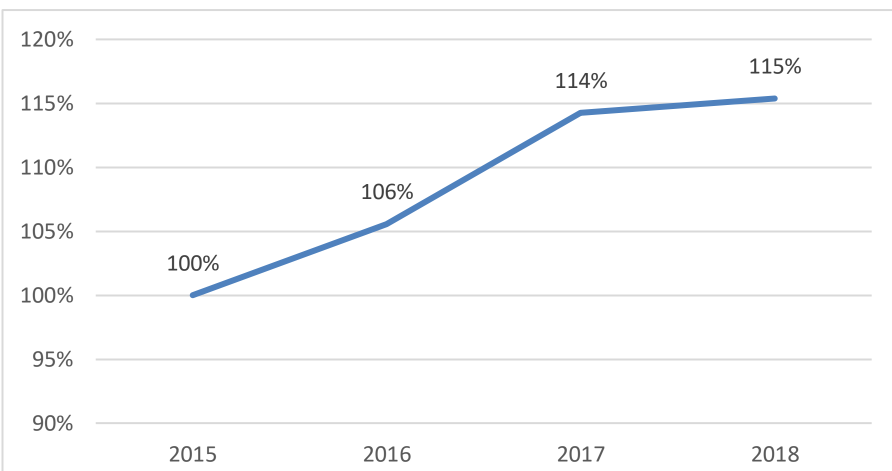
Estimated emissions associated with solid waste and wastewater management do not include emissions associated with the electricity and natural gas used in those operations. The electricity and natural gas for these operations are included in the overall community electricity and natural gas emission estimates for the Thurston region.

Figure 16: Distribution of waste and wastewater emissions in 2018 (%).



Waste-related emissions in 2018 were about 15% higher than waste-related emissions in 2015. Per-capita emissions were about 11% higher than per-capita emissions in 2015.

Figure 17: Waste Emissions (as percentage of 2015 emissions)



Solid Waste

Solid waste generated by Thurston County residents and businesses is collected and transported to the Roosevelt Regional Landfill in Oregon. Methane released during waste decomposition represented about 96% of solid waste emissions in 2018.

Table 13. Solid waste emissions (MTCO2e).

Solid Waste Management	2015	2018	% Change
Landfill emissions	113,402	132,988	17%
Process emissions	2,770	3,249	17%
Transportation Emissions	2,607	3,085	18%
Total	**118,779**	**139,322**	**17%**

Solid waste-related emissions increased by 17% between 2015 and 2018, while per capita emissions increased by 13% during the four-year period. This is largely due to the substantial increase in solid waste volumes. Factors contributing to the increased waste volumes include:

- Population: Thurston County's population increased by about 5% between 2015 and 2018.
- Reduced recycling opportunities: Recycled waste volumes have declined recently as the market for recycled materials has grown smaller.
- Economic conditions: Combined landfill and recycled waste volumes have increased during the 2015 – 2018 period along with the strong economic growth in Washington and the Thurston region.

Composting

Composting accounted for a very small portion (about 1%) of waste emissions in 2018 (1,838 MTCO2e). Emissions from composting activities in 2018 were about 10% higher than emissions in 2015.

Budd Inlet Treatment Facility

TCAT estimated that wastewater treatment operations at the Budd Inlet facility[13] emitted 538 MTCO2e in 2018. Emissions from the operation of the main wastewater treatment facility within the represented less than 1% of waste related emissions in 2018. Emissions from treatment operations include: (1) process emissions; (2) emissions from effluent discharges; (3) onsite gas digesters; and (4) the use of methanol to biologically treat waste.

Estimated treatment emissions do not include emissions associated with the electricity and natural gas used at wastewater treatment and conveyance operations. The emissions associated with the electricity and natural gas used for wastewater treatment operations are included in the overall community electricity and natural gas emission estimates for the Thurston region

Estimated GHG emissions increased by 19% between 2015 and 2018 while per capitate emissions increased by 15%. Most of the difference can be attributed to an increased customer base and higher nitrogen loading, although the latter falls well within the range of nitrogen loadings during the 2010 – 2017 time period.

[13] The Lacey Olympia Tumwater Thurston (LOTT) Clean Water Alliance Budd Inlet Treatment Plant.

Table 14: Emissions from Budd Inlet Wastewater Treatment Plant (MTCO2e)

LOTT - Budd Inlet	2015	2018	% Change
Process	162	216	33%
Digester	11	11	0%
Methanol	117	95	-19%
Effluent	162	216	33%
Total	**452**	**538**	**19%**

On-Site Septic Systems

Septic tanks collect wastewater on site and process it in underground tanks. Conditions in the tank are anaerobic where microorganisms produce methane gas as they biodegrade the soluble organic waste. Some of the methane produced during this degradation escapes from the septic systems into the atmosphere.

The Thurston County Health Department estimated that there were 54,172 and 53,000 on-site septic systems in Thurston County in 2015 and 2019, respectively. TCAT estimated the numbers of septic systems in 2016 and 2018 by linearly extrapolating between 2015 and 2109.

TCAT estimated that 16,635 MTCO2e were released from on-site septic tanks in 2018. This represents a small (about 2%) increase over emissions in 2015. This increase is virtually identical to the population growth in unincorporated Thurston County (2.1%) between 2015 and 2018.

Information Used to Estimate Waste Greenhouse Gas Emissions

TCAT estimated solid waste emissions by using the information on annual solid waste volumes provided by Thurston County Solid Waste (Romero, 2019 and 2020), information on solid waste characteristics published by Green Solutions, LLC, (2014), and default emission factors included in the updated Clearpath software model (ICLEI, 2019). When using the Clearpath software to estimate methane emissions from solid waste disposed at the Roosevelt Regional Landfill, TCAT assumed a "Typical" landfill gas collection scenario for 2010 and 2011 and an "Aggressive" landfill gas collection scenario for the 2012-2018 time period.

TCAT estimated composting emissions by using the information on annual organic waste collected provided by Thurston County Solid Waste (Romero, 2019 and 2020) and default emission factors included in the updated Clearpath software model.

There is a moderate amount of uncertainty surrounding solid waste management emission estimates. EPA calculated a 95 percent confidence interval for methane emissions from landfills of -9% to +9%. In other words, EPA calculated that there was a 2.5% chance that actual methane emissions are more than 9% lower than EPA's estimates and that there is a 2.5% chance that actual methane emissions are more than 9% higher than EPA's estimates.

TCAT estimated treatment-related emissions from the Budd Inlet Treatment Facility using information on the average daily digester gas production and fraction of methane in the digester gas provided by LOTT (Steffenson, 2019b), information on annual methanol use provided by LOTT (Steffenson 2019b), number of people served by LOTT (Steffensen 2019a), nitrogen loadings to Budd Inlet (Steffensen 2019c) and default emission factors included in the Clearpath software model.

There is a moderate amount of uncertainty surrounding wastewater emission estimates for the Budd Inlet Treatment Facility. EPA calculated a 95 percent confidence interval for methane emissions from landfills of -9% to +9%. In other words, EPA calculated that there was a 2.5% chance that actual methane emissions are more than 9% lower than EPA's estimates and that there is a 2.5% chance that actual methane emissions are more than 9% higher than EPA's estimates.

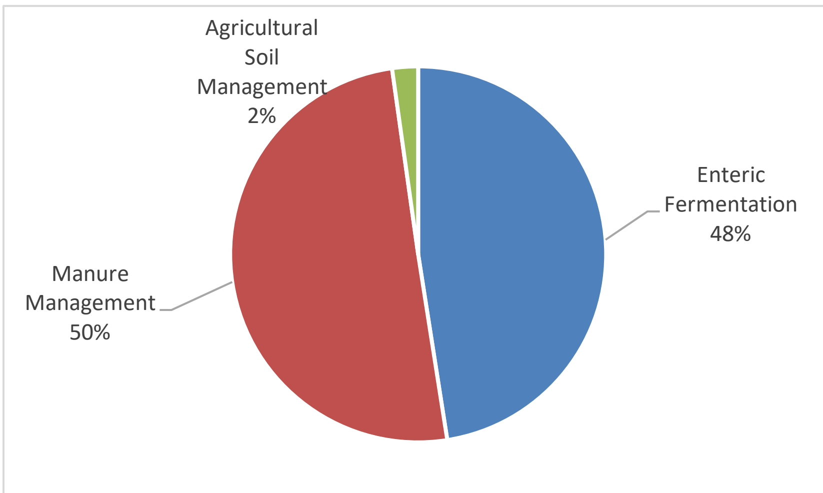
TCAT estimated emissions from on-site septic systems using information on the number of on-site systems provided by the Thurston County Health Department (PHSSD/EHD 2016) and standard emission factors contained in the Clearpath software model. There is a moderate to high amount of uncertainty associated with these estimates due to questions on the applicability of default emission factors.

Agriculture

Agricultural activities resulted in the release of an estimated 76,762 MTCO2e in 2018 which represented about 3% of Thurston County's carbon footprint. Emissions from enteric fermentation and manure management represented 48% and 50%, respectively, of estimated agriculture emissions in 2018.

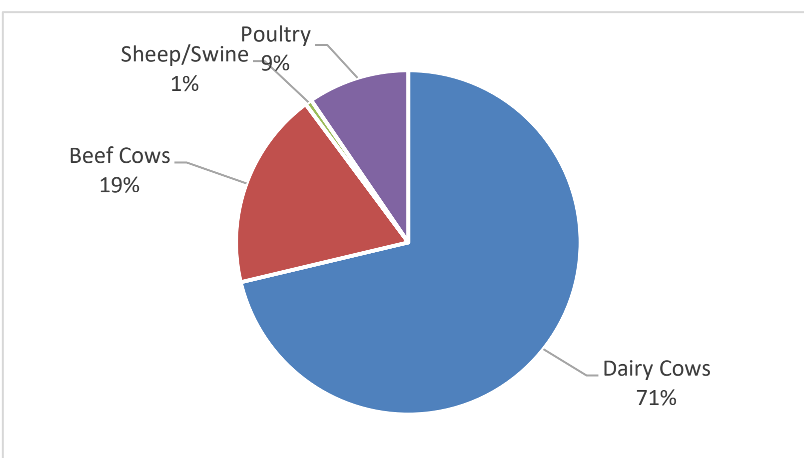
Estimated agriculture emission estimates do not include emissions associated with the electricity and natural gas used at agricultural facilities. These emissions associated with the electricity and natural gas used during agricultural operations are included in the overall community electricity and natural gas emission estimates.

Figure 18: Distribution of Emissions by Activity in 2018 (expressed as a % of Agriculture emissions).



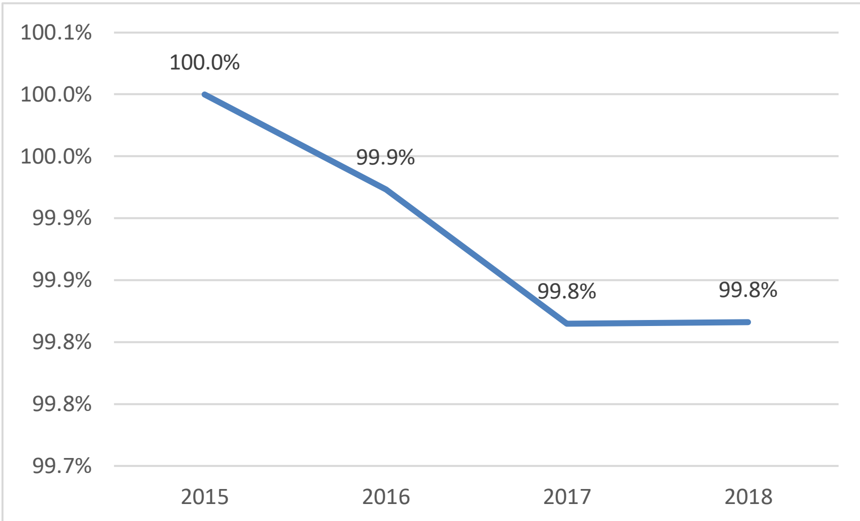
Activities associated with dairy farming contributed almost 66% of the emissions associated with agriculture.

Figure 19: Distribution of Emissions by Livestock in 2018 (expressed as a % of Agriculture emissions).



Emissions associated with agricultural activities remained largely unchanged between 2012 and 2017 when the two most recent agricultural census reports were published by the US Department of Agriculture. Per capita emissions in 2017 were about 5% lower than per capita emissions in 2015.

Figure 20: Trend in Agriculture Emissions in 2018 (expressed as a % of 2015 Agriculture Emissions).



Enteric Fermentation

Raising livestock can result in a large amount of greenhouse gas emissions since ruminants such as cows generate large amounts of methane as they digest their food. Enteric fermentation was the second largest contributor to AFOLU emissions (48%) in 2018. Emissions from dairy cows and beef cows represented about 61% and 37%, respectively, of enteric fermentation emissions in 2018. Emissions in 2018 were essentially the same as emissions in 2015.

Table 15: Enteric Fermentation Emissions (MTCO2e).

Enteric Fermentation	2015	2018	% 2018 Emissions	% Change
Dairy Cows	22,375	22,425	61%	0.2%
Beef Cows	14,084	13,642	37%	-3.1%
Swine	27	27	0%	0.0%
Sheep	393	386	1%	-1.7%
Total	**36,879**	**36,480**	**100%**	**-1.1%**

Manure Management

Manure management was the largest contributor to agricultural emissions (50%) in 2018. Emissions from manure management operations for dairy cows and poultry represented about 81% and 19%, respectively, of emissions from manure management in 2018. Emissions in 2018 were essentially the same as emissions in 2015.

Table 16: Manure Management Emissions (MTCO2e).

Manure Management	2015	2018	% 2018 Emissions	% Change
Dairy Cows	31,019	31,079	81%	0.2%
Beef Cows	308	280	1%	-9.1%
Swine	61	61	<1%	0.0%
Poultry	7,152	7,153	19%	0.0%
Total	**38,540**	**38,573**	**100%**	**0.1%**

Agricultural Soil Management

GHG emissions occur during nitrous oxide runoff and volatilization in row-crop systems. Agricultural soil management represented about 2% of agriculture emissions with 1,709 MTCO2e in 2018. Emissions from agricultural soils increased by about 15% between 2015 and 2018.

Table 17: Change in Agricultural Soil Management

	2015	2018	% Change
Soil management	1,485	1,709	15.1%

Information Used to Estimate Agriculture Greenhouse Gas Emissions

TCAT estimated agricultural livestock emissions by using information on the number of livestock and amount of agricultural lands (acres) in Thurston County published by the US Department of Agriculture (USDA, 2014 and 2019), Washington-specific emission factors published by the Environmental Protection Agency (EPA, 2019a), statewide manure management practices published by EPA (2019a) and default emission factors in the Clearpath software model.

There is a moderate–to-large amount of uncertainty surrounding agricultural livestock emissions. EPA (2017a) calculated a 95 percent confidence interval for methane emissions from enteric fermentation of -11% and 18%, respectively. In other words, EPA calculated that there was a 2.5% chance that actual methane emissions are more than 11% lower than EPA's estimates and that there is a 2.5% chance that actual methane emissions are more than 18% higher than EPA's estimates.

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Emission Sources Not Included in the Inventory

When preparing the August 2018 inventory report (TCAT, 2018), TCAT developed preliminary GHG emission estimates for several additional sources and/or categories that were ultimately not included in Thurston County Inventory. Some of these estimates were updated for 2017. In the earlier report, TCAT also developed preliminary estimates for a consumption-based emission inventory that provides an alternative approach for characterizing the County's carbon footprint. Information on other emission sources and consumption-based emission estimates are presented below.

Other Emission Sources

TCAT included preliminary GHG emission estimates for several additional sources and/or categories in the August 2018 report that were ultimately not included in the Thurston County Inventory. Local agencies may want to consider including some of these categories in future inventory efforts if they determine that tracking progress for additional sources would support community emission reduction strategies. These additional sources and categories are summarized in Table 18 and briefly discussed in the paragraphs below.

The following paragraphs provide additional background information on these source categories:

- Refrigerants and Fire Suppressants. Refrigerators and fire suppression equipment are important sources of hydrofluorocarbons (HFCs). HFCs are thousands of times more potent than carbon dioxide and are now subject to international requirements.[14] TCAT estimated the amount of HFCs released in Thurston County during the 2010 – 2018 time period by scaling the national emission estimates to Thurston County based on relative population sizes. Annual GHG emissions (MTCO2e) were estimated using the most current Global Warming Potential (GWP) values included in the Clearpath software model. TCAT decided not to include these estimates in the Thurston County inventory because local data on refrigerant and fire suppressant use are not readily available and there are limited opportunities for local government intervention to reduce these emissions.
- Residential and Business Air Travel. TCAT estimated that air travel by Thurston County residents was associated with 137,423 MTCO2e in 2017. These estimates were developed using fuel consumption data and passenger surveys for Sea Tac International Airport (Meyn, 2019). TCAT decided not to include air travel emissions because they are largely unaffected by local government actions.
- Other Transportation Sources. TCAT developed preliminary estimates for several other transportation sources: (1) Olympia Airport; (2) ships and boats; and (3) railroads. TCAT decided not to include these estimates because of data and method uncertainties, relatively small contributions to overall county GHG emission estimates and limited opportunities for local government actions (rail transportation).
    - Olympia Airport. TCAT prepared preliminary emissions estimates using information on jet fuel and aviation gas deliveries provided by the Port of Olympia (Liebel, 2017). In 2016, estimated airport emissions were 2,750 MTCO2e.
    - Recreational and Harbor Vessels. TCAT prepared preliminary emissions estimates using information from

[14] In October 2016, negotiators from 197 nations signed an agreement to amend the Montreal Protocol in Kigali, Rwanda. Under the Kigali agreement, these countries are expected to reduce the manufacture and use of hydrofluorocarbons (HFCs) by roughly 80-85% from their respective baselines, before 2045. This phase down is expected to slow the global average temperature rise by up to 0.5°C by 2100.

the Puget Sound Maritime Air Forum Air Emissions inventory (PSMAF, 2012 and 2017).[15]

- Rail Transportation. TCAT prepared preliminary emissions estimates using information from the Washington Department of Ecology (Ecology, 2018) and the US EPA (2019). In 2017, estimated railroad emissions were 28,730 MTCO2e. Freight rail was the largest contributor to railroad emissions in Thurston County (90%).

- Emissions Associated with Producing Transportation Fuels. TCAT developed preliminary estimates on the amount of GHGs emitted during the production of the gasoline and diesel fuel used in Thurston County's cars and trucks. The ICLEI (2013a) guidance estimates that fuel production emissions are equivalent to about 25% of the GHG emissions associated with the combustion of gasoline and diesel fuel.[16] These types of emissions are typically included in consumption-based emission inventories (see below). TCAT elected not to include these emissions in the Thurston County inventory in order to maintain consistency and comparability with the initial TCAT inventory and geographic-plus inventories prepared by other jurisdictions. (e.g., Seattle, Tacoma, Bellingham).

- Land Clearing: TCAT develop preliminary estimates on the emissions associated with clearing land for residential property development. Estimated annual emissions ranged from about 9,000 to 20,000 MTCO2e during the 2010 – 2018 time period. TCAT elected not to include these emissions in the Thurston County inventory because of uncertainties with (1) using national information on average lot sizes to characterize lot sizes in Thurston County; (2) uncertainties on using information from King County on forest canopy to Thurston County where there is a higher percentage of prairie lands.

- Other Wastewater Treatment Plants: There are several small wastewater treatment plants in Thurston County. TCAT reviewed the Department of Ecology's permit database to identify permitted facilities and developed a preliminary emission estimate for these facilities (77 MTCO2e) using available information on the total population served by these small plants. TCAT elected not to include these emissions in the Thurston County inventory because of (1) limited information on treatment processes; (2) uncertainties on the current populations served by these facilities; and (3) the estimated emissions represent an extremely small percentage of overall County emissions.

[15] The PSMAF inventory provides emission estimates for recreational vessels and harbor vessels. TCAT extrapolated the 2011 PSMAF estimates to other years using information on United States recreational vessel GHG emissions (EPA, 2017, Table A-118) and United States ships and non-recreational boats GHG emissions (EPA, 2017, Table -119).

[16] This approach is consistent with the methods used to estimate the overall emissions associated with electricity consumption. These methods include emissions associated with producing the fuels (e.g., coal and natural gas) that are used to produce the electricity used in Thurston County.

Table 18: Summary of Preliminary Emission Estimates for Source Categories Not Included in the Thurston County Geographic Plus Inventory

Category	MTCO2e[17]	Basis for Preliminary Estimate	Reasons for Not Including
Refrigerants and Fire Suppressants	100,000 -110,000	Used information on US emissions from the 2018 US GHG Inventory adjusted for population size.	Lack of local data and limited role for local government intervention.
Residential and Business Air Travel	96,000 – 140,000	ICLEI Equations TR.6.B.1 and TR.6.D.1 using fuel consumption data and passenger surveys provided by the Port of Seattle.	Limited role for local government intervention.
Olympia Airport	2,400 – 3,000	ICLEI Equation TR.6.B.1 using jet fuel and aviation gas data provided by the Port of Olympia.	Limited role for local government intervention and small % of county emissions.
Ships and Boats	4,000 – 5,000	PSMAF emission estimates for 2011 and 2016 extrapolated to other years using EPA national data.	Limited data, large uncertainty in estimates and small % of county emissions.
Railroads	28,700 – 31,000	Clearpath software using WDOE (2018) data on gallons of fuel used in county by passenger and freight trains in 2014 with extrapolation to other years using EPA national data.	Limited county-specific data and role for local government intervention.
Emissions From Producing Gasoline and Diesel Fuel	236,000 – 257,000	ICLEI Equation TR.9.1 using on-road transportation emission estimates for Thurston County	Comparability/Consistency with other local GHG inventories.
Land Clearing	9,000 – 20,000	Clearpath software using information on residential construction permits, national data on lot size and King County information on forest canopy.	Uncertainties associated with the applicability of national and King County data.
Other Wastewater Treatment Plants	77	ICLEI Equations WW. 7 and WW.12a using WDOE permits to estimate population served by smaller WWTPs.	Large uncertainties and small % of county emissions.

[17] Range of annual emission estimates for the 2010 – 2018 time period.

Consumption-Based Emission Inventory Estimates

Consumption-based emissions inventories (CBEIs) provide an alternate approach for characterizing a community's carbon footprint. CBEIs provide estimates of the global greenhouse gas emissions that result during the complete life cycle of goods and services consumed in a particular community or geographic area. This includes emissions during pre-purchase activities,[18] use[19] and post-consumer disposal.[20] For example, emissions associated with a household car includes emissions associated with manufacturing the car, producing the steel, aluminum and other materials used in manufacturing the car, transporting the finished car to dealerships, vehicle use, production of the gasoline and diesel fuels used when driving the car and final disposal of the car.

These types of inventories are based on several key premises:

- Purchase and consumption of goods and services is the primary cause of emissions.
- A full accounting of a community's climate impact needs to consider the total life-cycle emissions from cradle (the production phase) to grave (post-consumer disposal).
- Many of the emissions associated with producing the goods and services purchased and consumed in a community occur outside the community, but these emissions have the same effect on the global climate as emissions that physically originate within the community.

Several state and local communities have developed CBEIs:

- The Oregon Department of Environmental Quality has developed methods for estimating consumption-based emissions that they have used to develop a CBEI for the State of Oregon (DEQ, 2018).
- Several Oregon cities have used the information compiled by DEQ to incorporate consumption-based emission estimates into their local GHG inventories.
- King County has developed methods for estimating consumption-based emissions and used those methods to develop a CBEI for calendar year 2015 (Cascadia and Hammerschlag, 2017).
- The Washington Department of Ecology (Morris et al., 2007) has developed a tool that can be used to estimate consumption-based emission estimates for Washington State. Ecology used the tool to develop consumption-

[18] "Pre-purchase" includes most emissions prior to the point of purchase, including supply chain, supply chain transport, and final assembly and production. For services (including health care), pre-purchase emissions include all emissions associated with providing the service.

[19] "Use" includes the life-cycle emissions of fuels and electricity used to power lights, electronics, appliances, and personal vehicles, as well as trace emissions from refrigerants and vehicle lubricants.

[20] "Post-consumer disposal" includes the emissions from landfilling and incineration of purchased goods.

based estimates for 2005 through 2011.

TCAT developed a preliminary CBEI for the Thurston County for calendar year 2015 using information from the Oregon DEQ reports. The preliminary estimate includes emissions from households and governments, but not business capital and investments.[21]

- Thurston County Households. TCAT estimated that consumption by Thurston County households produced 4,882,000 MTCO2e in 2015.[22] Over two-thirds of household consumption-based emissions are associated with the following five categories: Vehicles and parts (22.6 %); Food and beverages (15.3%); Appliances (12.4%); Services (12.1%); and Healthcare (8.4%).
- Government: TCAT estimated that consumption by Thurston County governments produced 610,000 MTCO2e in 2015.[23]

Characterizing a community's total carbon footprint is not simply a matter of adding the CBEI with the geographic - plus inventory contained in this report. Oregon DEQ found that there is considerable overlap between the emission estimates prepared using a sector or geographic-plus approach and consumption-based emission estimates. Specifically, they estimated that Oregon's sector-based emissions and consumption-based emissions in 2015 were about 63 and 89 million MTCO2e, respectively. The two inventories shared about 38 million MTCO2e in common.[24] Consequently, simply adding together the two estimates would have overestimated the combined statewide GHG emissions by 33%.

Several Oregon cities (cities of Ashland, Corvallis and Lake Oswego) have used the information compiled by DEQ to incorporate consumption-based emission estimates into their local GHG inventories. For example, the city of Ashland estimated that consumption-based emissions associated with the residential consumption of goods and food represented almost 37% of Ashland's GHG footprint during calendar year 2015.

A consumption-based emission inventory could provide a valuable tool for local governments seeking to understand the global implications and tradeoffs associated with different control strategies. For example, when replacing older vehicles with newer more fuel-efficient ones, potential buyers should consider the global emissions associated with manufacturing a new vehicle as well as the reduced energy consumption and emissions during vehicle use.

TCAT decided not to include the preliminary CBEI estimates in the Thurston County inventory because (1) lack of readily available local data needed to estimate consumption-based emissions in Thurston County (2) uncertainties in extrapolating information from other consumption-based emission inventories (particularly for government and

21 TCAT did not develop a preliminary CBEI for business capital/investment because of the uncertainties associated with extrapolating the Oregon business capital/investment estimates to the Thurston region.

22 TCAT developed the preliminary CBEI for households using the following information: (1) Average per-household consumption-based greenhouse gas emissions (MTCO2e/HH) by income category was obtained from Table B-4 in ODEQ (2018b); (2) Information on the number of Thurston County households by income category in calendar year 2015 was obtained from the US Census Bureau (2018); (3) Household greenhouse gas emissions were estimated for each income category by multiplying the per household emissions in Table B-4 by the total number of Thurston County households in that income category; and (4) Total household greenhouse gas emissions were estimated by summing emission estimates for all income categories.

23 TCAT developed the preliminary CBEI for governments by assuming that the relationship between government and household emissions (e.g., government emissions represent 12.5% (1/8) of household emissions) is the same for the Thurston region and the State of Oregon. This relationship is similar to ratio of government and household emissions observed in King County (13.3%). This may underestimate government consumption-based emissions in the Thurston region given that the percentage of the overall workforce represented by government employees is much higher in Thurston County (31% of Thurston County's employed population is classified as government workers by the US Census Bureau) than the State of Oregon (16.2%) and King County (12.4%).

24 Emissions common to both inventories include emissions from household and government use of energy and waste disposal.

business capital/investment) and (3) concerns about overlaps with the source categories included in the Thurston County inventory that could lead to double-counting emissions.

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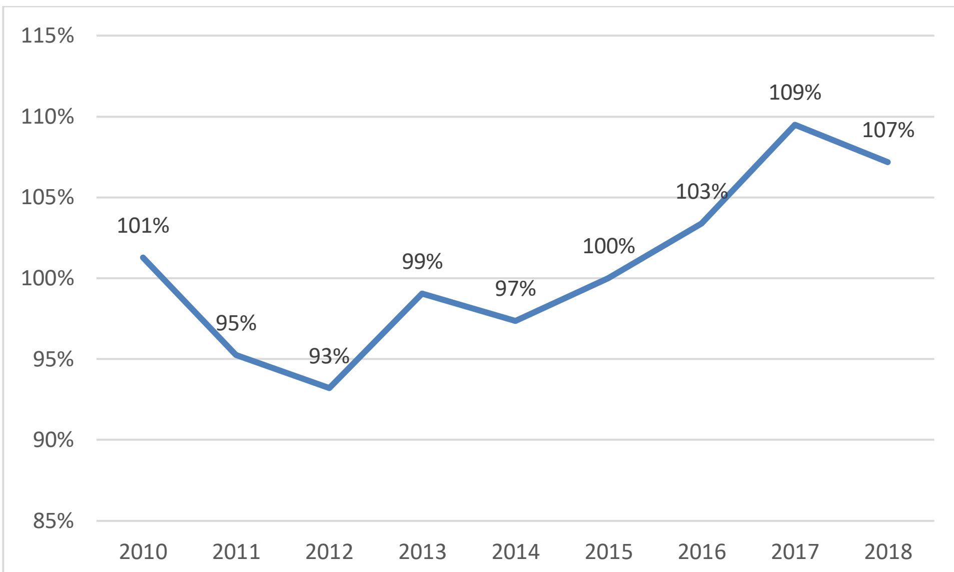
Conclusions

Lacey, Olympia, Tumwater and Thurston County are preparing a regional climate mitigation plan. As part of this effort, each jurisdiction has adopted common regional climate mitigation targets (TRPC, 2020f):

- 45% reduction below 2015 levels by 2030, and
- 85% below 2015 levels by 2050.

TCAT found that Thurston County was able to make meaningful progress on reducing emissions when emissions between 2010 and 2012 fell by about 8% (average annual decline of about 4% per year). That progress was reversed during the subsequent five years when emissions rose by about 17% (average annual increase of more than 3% per year) before declining by about 3% in 2018. Regional emissions were about 7% higher in 2018 than emissions in 2015 (the baseline year for evaluating progress on achieving the region's climate mitigation goals).

Figure 20: Thurston County greenhouse gas emissions (2015 emissions = 100%).



Achieving the Thurston region's climate goals will require larger annual emission reductions than those achieved between 2010 and 2012. Reducing emissions by 85% below 2015 levels by 2050 will require average annual reductions of about 6%/year.[25] In other words, achieving the emission reduction targets for 2050 (85% below 2015 levels) will require that emissions are reduced by 6% every year between 2020 and 2050.

Achieving the annual emissions reductions needed to meet the 2035 and 2050 goals will require substantial changes to the region's energy sources, transportation and building energy consumption. One note of optimism is that implementation of existing state and federal laws could produce significant emission reductions in the Thurston region. For example, the Washington Clean Energy Transformation Act was signed into law on May 7, 2019. The new law requires electric utilities

25 TCAT used a simple exponential model to estimate the annual emission reductions needed to achieve the regional climate mitigation goals. Using a linear model, annual reductions of about 93,000 MTCO2e/year. This represents about a 2.8% reduction in 2020 and over 20%/year as we approach 2050.

to provide electricity that is generated with a 100% non-emitting and renewable resources by 2045.[26] Full implementation of the new law will result in significant reductions the Thurston region's GHG footprint over the next three decades given that emissions associated with the generation, distribution and use of electricity contributed over 40% of the region's emissions in 2018.

[26] The new law established a series of deadlines for achieving the 100% renewable goal. Specifically, electric utilities must: (1) Eliminate coal-fired resources from the electric power supply by 2025; (2) achieve a carbon neutral energy supply by 2030 (with at least 80% non-emitting and renewable resources); and (3) achieve a carbon-free energy supply by 2045 (100% non-emitting and renewable resources).

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