Community and Government Operations Greenhouse Gas Emissions Inventory

2016

Office of
Environmental Policy
and Sustainability

Tacoma

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Tacoma's GHG Inventory Overview

The City of Tacoma takes its role of environmental stewardship seriously. In April 2005, Mayor Bill Baarsma signed the initial U.S. Mayors Climate Protection Agreement (MCPA), committing Tacoma to reduce its greenhouse gas (GHG) emission levels to the Kyoto Protocol target of 7 percent below 1990 levels by 2012. Tacoma's 2008 Climate Action Plan (CAP) laid out overall greenhouse gas emission reduction goals, emphasized mitigation measures and established the Office of Environmental Policy and Sustainability and the Sustainable Tacoma Commission.

The City has taken several actions to reduce municipal GHG emissions, including moving to every-other-week solid waste and recyclables pick-up, initiating a commercial food waste to biogas program and adding low or no-emission vehicles to the overall fleet. For example, the Solid Waste Division has made great strides, having converted 48% of the eligible waste-hauling vehicles to compressed natural gas (CNG) or hybrid technology, with more to follow.

For nearly a decade, the City has generated estimates of GHG emissions and tracked them against the Kyoto Protocol, internal CAP goals and now the Paris Accord goal. In 2016, the Environmental Action Plan was adopted which updated and expanded the Climate Action Plan. With sections on building energy; transportation; materials management; natural systems; air and local food; and climate resiliency, it added specific targets and goals for both municipal and private sector actions. Many of these actions can have a positive effect on GHG emissions reductions if actualized.

One benefit of the City's membership in ICLEI (Local Governments for Sustainability) is the use of a leading online software platform, ClearPath™, for performing GHG emissions inventories. This on-line software is the dominant one used by local governments and consultants in the United States. Two inventory modules are available, one for the "Community", or primarily the private sector, and another for "Government Operations". This inventory used both modules and combined the output values for a full inventory of the City of Tacoma's estimated GHG emissions.

For nearly a decade, the City has generated estimates of GHG emissions and tracked them against the Kyoto Protocol, internal CAP goals and now the Paris Accord goal.

Greenhouse Gas Emissions Reduction Goals

The three goals Tacoma tracks against are listed in the table below and illustrated compared to estimated emissions in the figure below.

Agreement	Goal
Kyoto Protocol	7% below 1990 levels by 2012
Tacoma Climate Action Plan	15% below 1990 levels by 2012 80% below 1990 levels by 2050
Paris Accord	26-28% below 2005 levels by 2025

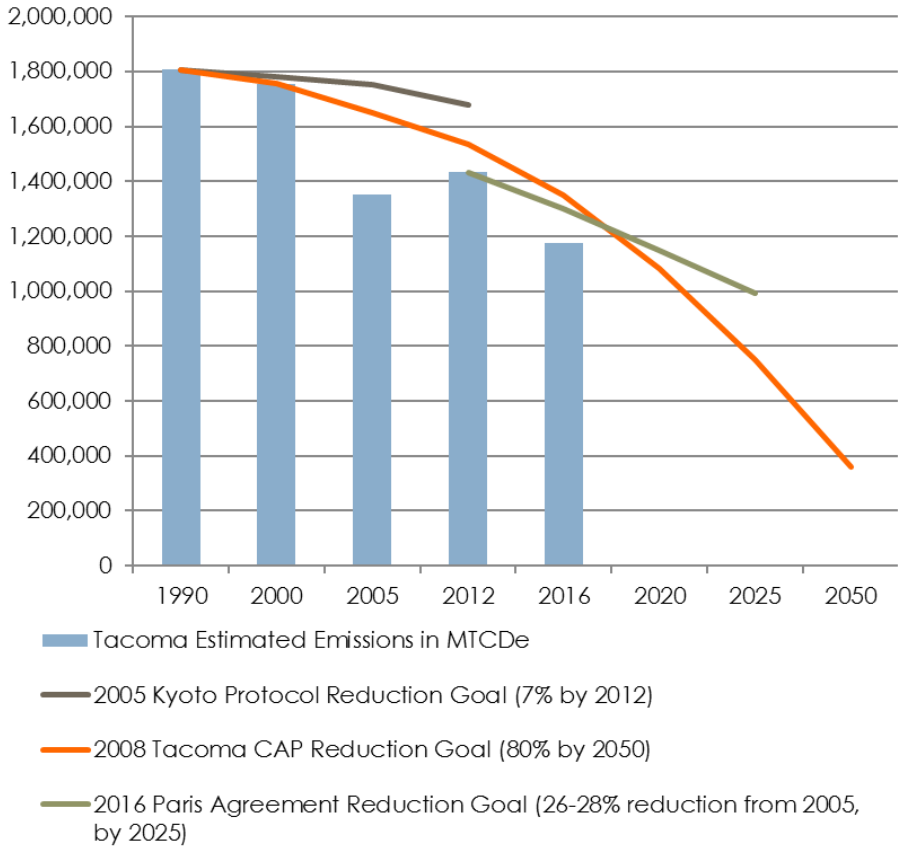

Figure 1: *Tacoma GHG estimated emissions 1990 – 2016, compared to reduction goals.*

Since the Kyoto Protocol, 1990 has been used as a common baseline for many jurisdictions producing inventories and tracking goals. That goal had an endpoint in 2012, and with the Paris Accord establishment of 2005 as baseline, some are using or revising baselines to that or other intermediate years. For broader context; some regional and state, as well as national GHG emission goals are below.

Jurisdiction	Goal
City of Tacoma	80% below 1990 levels by 2050
City of Seattle	Zero net emissions by 2050
King County	80% below 2007 levels by 2050
Snohomish County	20% below 2000 levels by 2020
Pierce County	No goals currently
Puget Sound Clean Air Agency (PSCAA)	80% below 1990 levels by 2050
State of Washington	1990 State level by 2020 25% below 1990 State level by 2035 50% below 1990 State level by 2050
State Department of Ecology recommendation* * "This recommendation is consistent with limits that other industrialized jurisdictions that are committed to addressing climate change are pursuing."	1990 State level by 2020 40% below 1990 State level by 2035 80% below 1990 State level by 2050
United States (2009) Kyoto Protocol	17 % below 2005 levels by 2020 80 % below 2005 levels by 2050
United States (2016) Paris Agreement	26-28% below 2005 levels by 2025

Table 1: *Selected local, regional, state and national GHG emissions reduction goals.*

2016 Inventory Key Findings

Community Estimated Emissions

The 2016 total estimated GHG emissions in the community inventory come from two primary sources: fossil fuels for transportation (71%) and energy for buildings (24%). The remainder (5%) comes from a combination of methane emissions from the former City landfill and those from GHG-producing materials (paper, cardboard, food and other organics) that are currently landfilled in the county landfill. Total community emissions account for 94% of the City's total estimated emissions.

Community estimated emissions show a fairly dramatic decline of about 20%, but this is a result of a large drop in natural gas consumption by one industrial customer. There was an 84% decline in emissions within the industrial energy sector; a condition which will not remain in place and does not indicate a trend. More detail will be discussed in the Building Energy section below.

On a per resident basis, total community emissions estimates decreased 21.83% and per household, by 26.50%, from 2012.

Community including Industrial				Excluding Industrial		
Emission Source	**2012**	**2016**	**2012-16 % Diff**	**2012**	**2016**	**2012-16 % Diff**
Buildings	**579,539**	**270,050**	**-53.40%**	**265,303**	**220,209**	**-17.00%**
Residential	150,318	132,823	-11.64%	150,318	132,823	-11.64%
Commercial	114,985	87,386	-24.00%	114,985	87,386	-24.00%
Industrial	314,236	49,841	-84.14%			
Transportation	**741,820**	**785,624**	**5.90%**	**741,820**	**785,624**	**5.90%**
Gasoline	556,389	589,189	5.90%	556,389	589,189	5.90%
Diesel	156,897	170,232	8.50%	156,897	170,232	8.50%
Pierce Transit	28,534	26,203	-8.17%	28,534	26,203	-8.17%
Solid Waste	**38,146**	**45,437**	**19.11%**	**38,146**	**45,437**	**19.11%**
Landfilled Materials	38,146	45,437	19.11%	38,146	45,437	19.11%
Community Total	**1,359,505**	**1,101,111**	**-19.01%**	**1,045,269**	**1,051,270**	**0.57%**
Per Resident	6.73	5.30	**-21.32%**	5.17	5.06	**-2.35%**
Per household	18.19	13.46	**-26.02%**	13.99	12.85	**-8.86%**

Table 2: *Community estimated greenhouse gas emissions from 2012 and 2016, with and without the Industrial sector. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDe).*

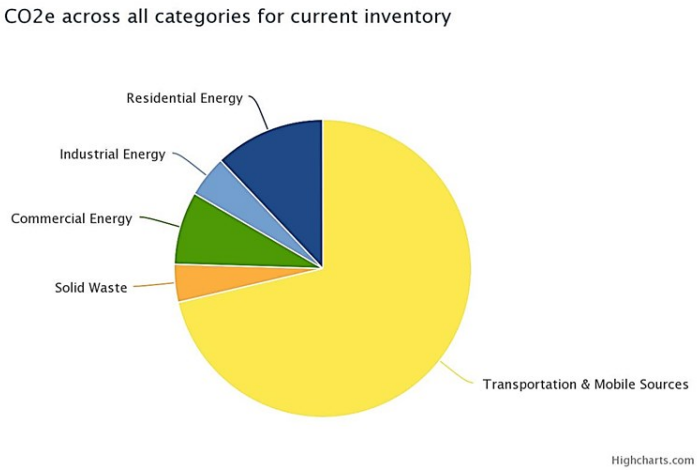

Figure 2: *Community proportional GHG estimated emissions in 2016.*

Transportation

As has been the case since inventories began in 1990, on-road transportation accounts for the predominant source of GHG emissions. The dominance of relatively clean hydropower for electricity in our region results in transportation taking on a larger proportion of GHG emissions relative to other sources and swelling or shrinking as other categories decrease or increase.

The transportation category includes gas and diesel fuel vehicles as well as Pierce Transit vehicles of various fuel types. There was an overall increase of 5.9% compared to 2012, although Pierce Transit dropped 8.17% in the same period. Pierce Transit's proportion of emissions has been only about 2% of total estimated emission since at least 2005. Pierce Transit is still working on restoring service hours caused largely by the impacts of the Great Recession.

Estimates for non-transit gasoline-fueled vehicles increased 5.9% and those of non-transit diesel fuel vehicles increased by 8.5% from 2012 to 2016.

The framework for on-road transportation excludes off-road uses, such as construction and lawn equipment, Sound Transit Sounder and Link, passenger and freight rail service and any marine vessels. (Tacoma Rail emissions are included in Government Operations/Vehicle Fleet/Off-road vehicles.) Tacoma Link light rail electricity use is reflected in Building energy use figures, as are all electrified vehicles. ST Express bus services emissions are not specifically captured in this inventory, due to the dominance of out-of-boundary mileage. Pierce Transit VMT is not able to be factored for just Tacoma at this time, so there is some overstatement of their emissions within the Tacoma boundary.

Building Energy

In the community category, emission estimates of energy use in buildings are broken down into residential, commercial, and industrial sectors. Tacoma Power (the municipal utility providing electricity) notes that they categorize only the largest customers as industrial. Building energy makes up an estimated 25% of entire community emissions and 23% of those citywide.

The reduction in natural gas use by a single industrial customer was the primary cause for a significant drop

The reduction in natural gas use by a single Industrial customer was the primary cause for a significant drop (84%) in the industrial sector

(84%) in that sector, according to Puget Sound Energy (PSE, the utility providing natural gas). If the industrial energy sector is isolated and removed from 2012 and 2016, the building category declined by 17%, rather than 53%, and the increase in Community estimated emissions were 0.57%, rather than -19%. Industrial emissions grew 24% from 2005 to 2012 and growth will continue again in the future. The swing from a 24% increase to an 84% decrease in 2016 is clearly an aberration. Likewise, per resident and per household figures between 2012 and 2016 dropped precipitously from 21% to 2% and 26% to 9%, respectively.

Increasing efficiency in both buildings and equipment, due to higher requirements in codes and standards do make a difference.

The building category emissions decreased in all energy sectors, with residential and commercial seeing decreases of 12% and 24% respectively. Warmer winter weather in 2016 was certainly a factor, with 4,739 heating degree days (HDD) compared to 5,552 in 2012 and 5,181 in 2005.

The number of residential natural gas customers increased by 717 between 2005 and 2016, while the commercial sector decreased by 86 and industrial by 31, in the same period. Therefore, while there has been growth in smaller users, larger users of natural gas have decreased, which would have a general lowering effect on related GHG emissions.

Increasing efficiency in both buildings and equipment, due to more stringent requirements in codes and standards (i.e. ENERGY STAR®), do make a difference. TPU notes that "big hitters" in higher efficiency include:

- Continued replacement of refrigerators (even without any TPU incentive program)
- Upgrading to flat panel from CRT televisions
- Increasing adoption of LED lighting (within or outside TPU incentive programs)
- Increased use of heat pump systems which provide both efficient heating and cooling
- Increased multifamily construction, which is more efficient per person

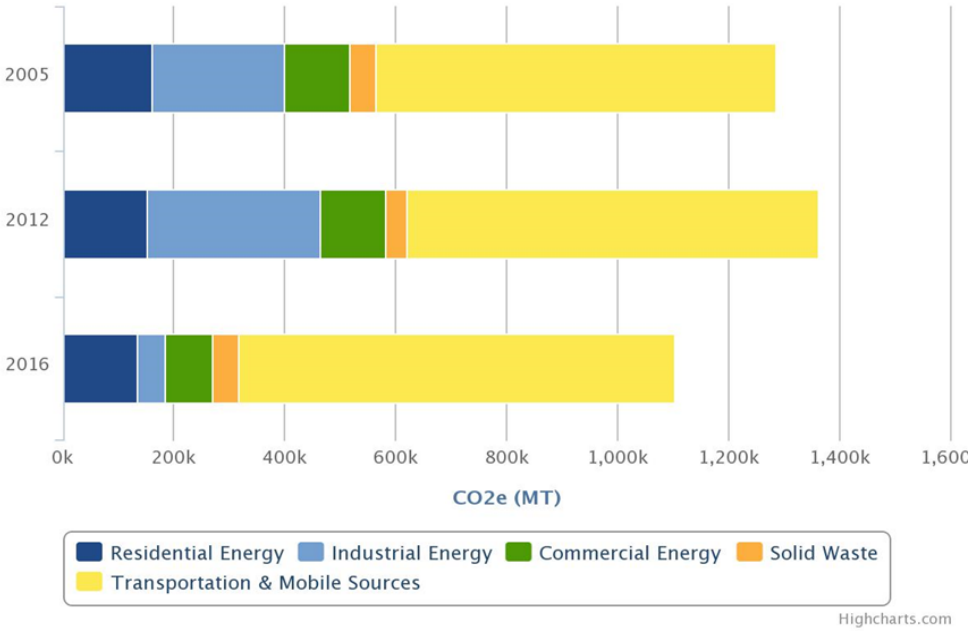

Figure 3: *2005, 2012 and 2016 Community GHG estimated emissions by sector.*

Solid Waste

The community solid waste estimates are based on GHG-producing waste items (paper, cardboard, food and other organics) sent to the landfill in Pierce County. Estimated emissions from landfilled GHG-producing waste represent roughly 4% of total community estimated emissions.

Government Operations Estimated Emissions

While Community estimated emissions decreased 19%, estimated emissions in Government Operations were basically flat, at 0.07%. Total government operations estimated emissions account for 6% of the City's total emissions.

Building energy use decreased 15% and water/ wastewater treatment by 4%. Fleet decreased by 1%. Although streetlights and signals saw an estimated increase of 9%, these emissions relative to other categories are quite low and there are data challenges since many streetlights are not metered. Switching to LED light sources will expand in 2018.

Estimated Emissions - Government Operations					
Emission Source	2005	2012	2005-12 % Diff	2016	2012-16 % Diff
Buildings	1,797	2,263	20.59%	1,962	-15.34%
Fleet	21,912	18,576	-17.96%	18,380	-1.07%
Employee Commute	44,361	50,538	12.22%	50,961	0.83%
Streetlights/Signals	570	498	-14.46%	547	8.96%
Water/Wastewater	741	663	-11.76%	636	-4.24%
Solid Waste	0.04	0.04	0.00%	0.04	0.00%
Gov. Ops Total	69,381	72,538	4.35%	72,486	-0.07%
Per Employee	18.37	22.65	18.89%	20.71	-9.35%
	2005	2012		2016	
City Total	1,351,879	1,432,043	5.60%	1,173,597	-22.02%

Table 3: *Government Operations estimated GHG emissions from 2005, 2012 and 2016Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDe).*

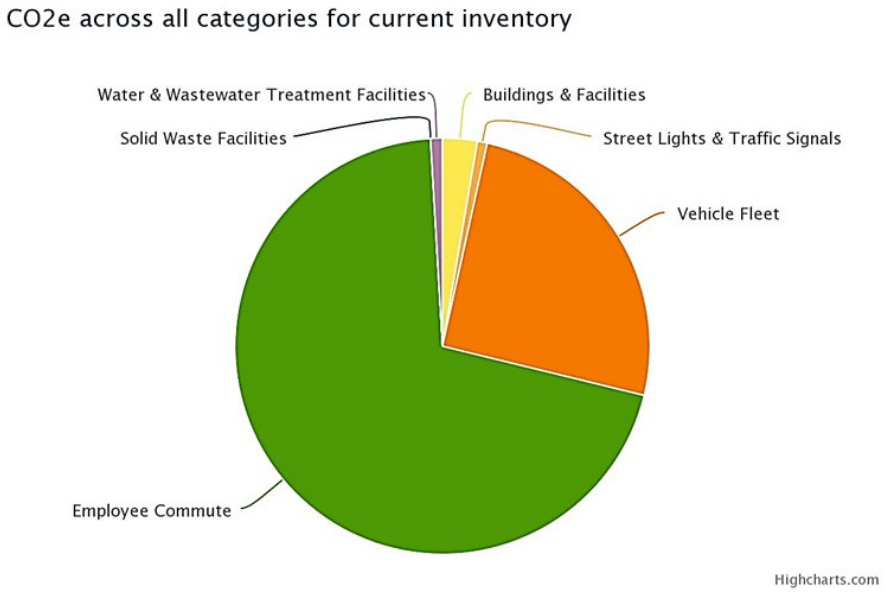

Figure 4: *Government Operation proportional GHG estimated emissions in 2016.*

Building Energy

The Government Operations building energy inventory includes all municipal buildings and facilities and their equipment except those related to supplying water and treating wastewater. These last two constitute their own category since these services utilize commercial equipment and are often not within the jurisdictional boundary of a city or county. Estimated emissions from city-owned buildings and facilities represent roughly 3% of total estimated emissions from government operations. Estimated emissions fell 15% from 2012.

Government Transportation Fleet

Emissions from fleet vehicles and self-reported employee commute choices make up the transportation category and represent the largest proportion of Government Operations total emissions, at 96%. The fleet represents 25% and employee commute 70% of those emissions. Fleet emissions have decreased from 32% to 26% since 2005, while employee commute rates have increased from 64% to 70%, with increases in single occupancy vehicle (SOV) and slight declines in carpool/vanpool.

Transportation emissions estimates do not include electric vehicles, since the charging of EV batteries is reflected in building energy use. Electrification of vehicles results in much lower (hybrids) or no emissions (plug-in hybrids or all electric).

TPU has 38 all-electric vehicles and many hybrids. The use of B20 (petroleum fuel with 20% bio-based) has declined to 69,000 gallons in 2016 from a high of 117,268 in 2011. Mobile fueling for the Central Treatment Plant was discontinued at the end of 2013 by the vendor, due to the challenges related the wide dispersion of vehicles. Service has continued at Solid Waste and Tacoma Power. Fleet fuel used in 2016 dropped nearly 43,000 gallons from 2012, while miles driven increased by 177,540 miles, indicating improvements in efficiency.

General Government owns 7 all-electric vehicles and several hybrids. Solid Waste Management has converted 48% of their eligible fleet to CNG or hybrid technology. The Division currently operates 30 CNG and 8 hybrid waste collection vehicles out of the 79 targeted for conversion. According to Solid Waste Management, implementing every-other-week pick-up is estimated to have lowered Co2 by 231,847 fewer pounds in just the first quarter of 2014.

Employee Commute

Employee commute includes single-occupancy vehicles (SOV), vanpools and carpools. The SOV mode is the most common by far, with nearly 16,000,000 vehicle miles travelled (VMT) in 2016, compared to about 1,800,000 VMT in vanpools and 1,000,000 in carpools. Total VMT in Employee commute decreased slightly in 2016, but there were 277 fewer employees compared to 2012. Pierce Transit had drastic service cutbacks during the recession and is only starting to restore service hours to previous levels.

Streetlights/Signals

Emission numbers from streetlights and signals are relatively small and continued conversion to LED technology should push a downward trend. Streetlights and signals represent roughly 1% of total estimated emissions from government operations.

Water Supply/Wastewater Treatment

Water supply facilities/operations and wastewater treatment operations together comprise about 1% of the total government emissions. Within wastewater treatment emissions those attributed to the central treatment plant digester operations are further broken out. Again, many jurisdictions do not have digester operations and they utilize unique processes and equipment. Estimated emissions from digester operations represent roughly 0.007% of total estimated emissions from government operations. The biogas is used to fuel boilers to heat the treatment plant and residual is burned in a flare.

Solid Waste

A government operations facet of solid waste management is collecting and flaring of methane gas from the closed landfill. This was not included in previous reporting periods but is a very small value (0.04 MTCDe). Reporting methane emissions to the Washington State Department of Ecology was not required in 2005, so the 2012 number was used as a place marker for 2005 emissions.

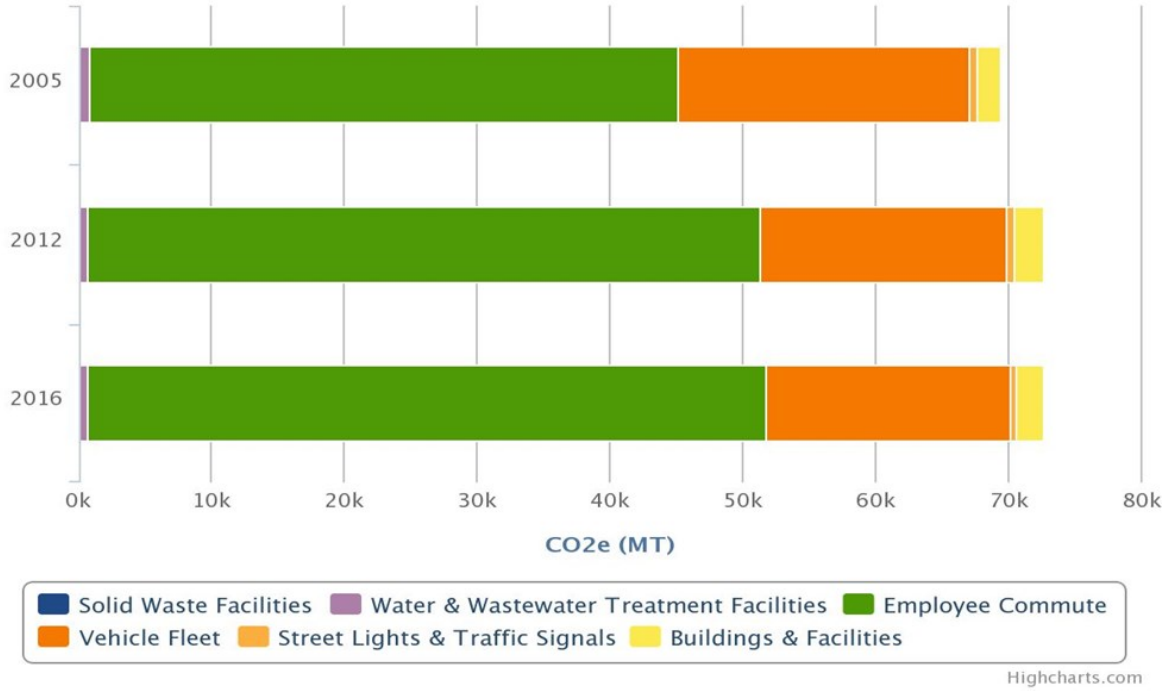

Figure 5: *2005, 2012 and 2016 Government Operations GHG estimated emissions by sector.*

Estimated Emissions - Community Sources and Activities					
Emission Source	**2005**	**2012**	**2005-12 % Diff**	**2016**	**2012-16 % Diff**
Buildings	**514,862**	**579,539**	**11.16%**	**270,050**	**-53.40%**
Residential	159,482	150,318	-6.10%	132,823	-11.64%
Commercial	117,744	114,985	-2.40%	87,386	-24.00%
Industrial	237,636	314,236	24.38%	49,841	-84.14%
Transportation	**720,729**	**741,820**	**2.84%**	**785,624**	**5.90%**
Gasoline	559,211	556,389	-0.51%	589,189	5.90%
Diesel	135,735	156,897	13.49%	170,232	8.50%
Pierce Transit	25,783	28,534	9.64%	26,203	-8.17%
Solid Waste	**46,907**	**38,146**	**-22.97%**	**45,437**	**19.11%**
Landfilled Materials	46,907	38,146	-22.97%	45,437	19.11%
Community Total	**1,282,498**	**1,359,505**	**5.66%**	**1,101,111**	**-19.01%**
Per Resident	6.47	6.73	3.80%	5.30	-21.32%
Per Household	16.27	18.19	10.55%	13.46	-26.02%

Estimated Emissions - Government Operations					
Emission Source	**2005**	**2012**	**2005-12 % Diff**	**2016**	**2012-16 % Diff**
Buildings	**1,797**	**2,263**	**20.59%**	**1,962**	**-15.34%**
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Solid Waste	**0.04**	**0.04**	**0.00%**	**0.04**	**0.00%**
Gov. Ops Total	**69,381**	**72,538**	**4.35%**	**72,486**	**-0.07%**
Per Employee	18.37	22.65	**18.89%**	20.71	**-9.35%**
	2005	**2012**		**2016**	
City Total	**1,351,879**	**1,432,043**	**5.60%**	**1,173,597**	**-22.02%**

Table 4: *GHG estimated emissions from both Community and Government Operations in 2005, 2012 and 2016. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDe).*

Conclusion

The year 2016 was an interesting year to do a GHG inventory. The loss of a single industrial user of natural gas created a huge drop in the Community building category emissions and skewed the Community transportation category to unprecedented heights. At the same time, warmer weather the last couple of years has definitely worked in favor of lower emissions in the building category.

In 2012 the City of Tacoma exceeded the Kyoto Protocol goal by 17%. Indicators point to being on track to meet the Paris Accord goal, but it will be challenging to meet the internal CAP goal of 80% reduction from 1990 by 2050. The trend line of emissions to goals illustrates this and it should be noted does not factor projected population increases regionally or locally.

PSRC reported Pierce County population grew by 1.8% in 2016-17, and Tacoma by 4.9%, one point lower than Sumner. Surrounding cities grew at higher rates than Tacoma, some substantially, such as Ruston at 30.2% and Gig Harbor 34.2%. Even Steilacoom exceeded Tacoma's growth rate, at 7.1%. Most likely pass-through traffic of passenger and freight vehicles will continue to increase with population growth and an improving business environment. Indications are strong that Tacoma may not reach the 2050 goal without enhanced and expanded efforts.

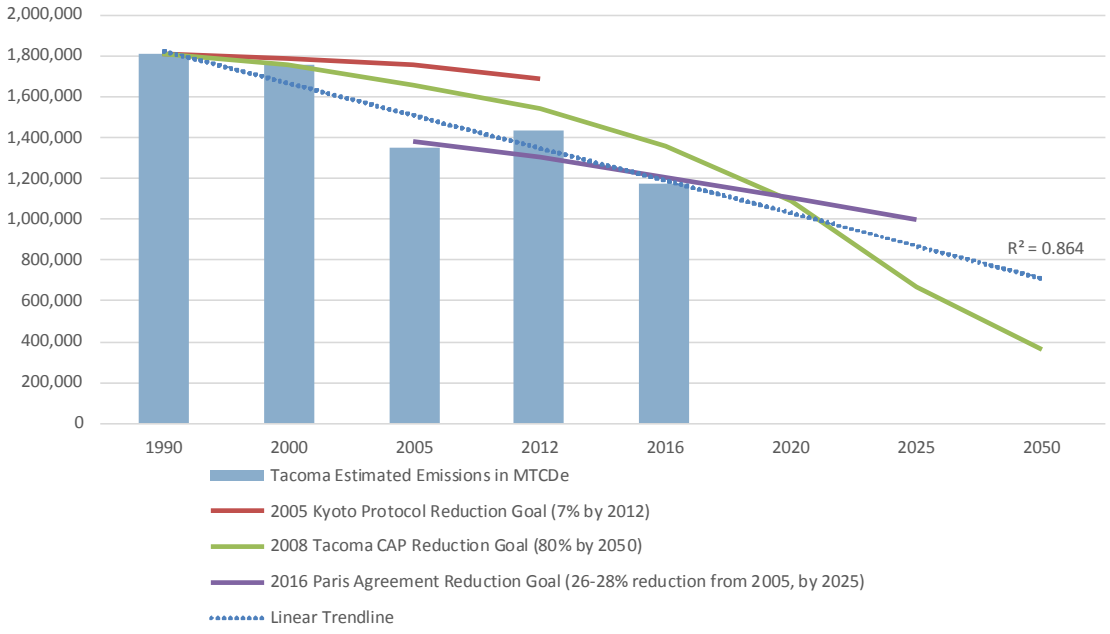


Figure 6: *Trend of Tacoma GHG estimated emissions, compared to reduction goals.*

Appendices

Appendix A: Inventory Methodology

It is recommended to conduct GHG emissions inventories every several years in order to track performance and recognize trends over time within a given community or jurisdiction. In addition, GHG inventory reports can demonstrate accountability and leadership, motivate community action, inform climate action planning, enable aggregation of data across regions and recognize GHG emissions performance compared to other similar communities over time.

The U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions, V 1.1, July 2013 (i.e., Community Protocol) is a national standard developed by ICLEI-USA and was funded by Pacific Gas and Electric Company, the State of Oregon Department of Environmental Quality, and through a National Science Foundation grant from the Research Coordination Network led by Dr. Anu Ramaswami at University of Colorado Denver. It was vetted by dozens of industry experts working in local, state, and federal governments, as well as universities, non-governmental organizations, and private corporations across the United States and Canada.

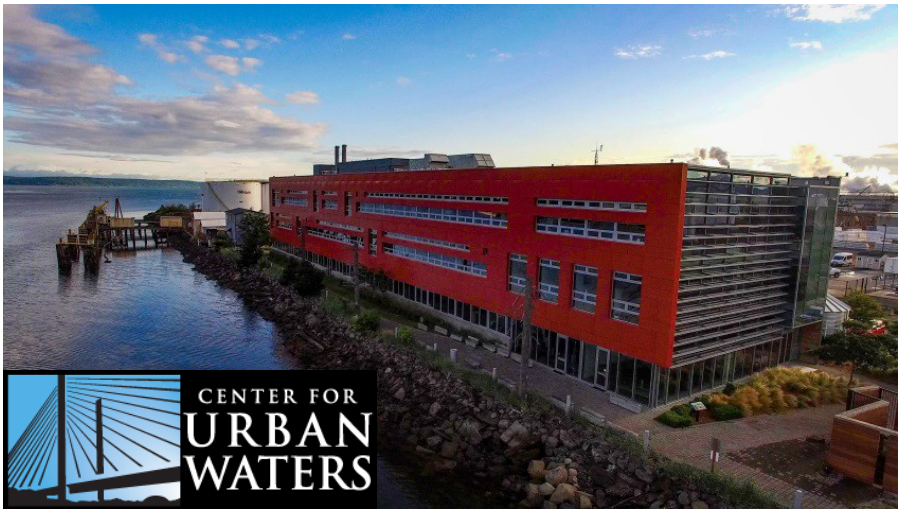
The Local Government Operations Protocol, V. 1.2, 2010, was developed through collaboration between ICLEI, the California Air Resources Board, the California Climate Action Registry, and The Climate Registry. It is considered the official standard for local governments in the United States who wish to prepare and report GHG estimated emissions. It was vetted by dozens of industry experts working in local, state, and federal governments, as well as universities, non-governmental organizations, and private corporations across the United States.

Reporting Timeframe

This inventory reports GHG estimated emissions produced between January 1, 2016 and December 31, 2016. In some cases, data was not available for 2016, in which case data from the closest year was used.

Data Collection

The City of Tacoma has performed estimates of GHG



emissions since 2007, using available data and a variety of calculation methods, including use of the predecessor software to ClearPath™. In 2017 it was decided to re-run the 2005 and 2010 years' data, as well as the 2016 data, in ClearPath™ in order to ensure consistent calculation methods. In several cases data was obtained from sources for all three reporting years as a validation method and input into the tool. This also ensures the use of the global warming potentials of the 2nd IPCC Assessment Report (1995) for all three of the most recent inventories.

Global Warming Potentials of Greenhouse Gases

There are six internationally recognized GHGs regulated under the Kyoto Protocol and the Paris Agreement:

- (Carbon Dioxide (CO2)
- Methane (CH4)
- Nitrous Oxide (N2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride (SF6)

These are measured in five emission categories: built environment; transportation and other mobile sources; solid waste; water and wastewater and agriculture.

Greenhouse gases (GHGs) warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space; they act like a blanket insulating the Earth. Different GHGs can have different effects on the Earth's warming. Two key ways in which these gases differ from each other are their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere (also known as their "lifetime").

Three factors affect the degree to which any GHG will influence global warming:

- Its abundance in the atmosphere
- How long it stays in the atmosphere
- Its global-warming potential

The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO2). The larger the GWP, the more that a given gas warms the Earth compared to CO2 over that time period. The time period usually used for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gases.

Greenhouse Gas	Chemical Formula	GWP per 2nd IPCC Assessment Report (1995)	GWP per 4th IPCC Assessment Report (2007)	GWP per 5th IPCC Assessment Report (2014)
Carbon Dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous Oxide	N_2O	310	298	265
Hydrofluorocarbons	$C_xH_yF_z$	Various	Various	Various
Perfluorocarbons	C_yG_y	Various	Various	Various
Sulfur Hexafluoride	SF_6	23,900	22,800	23,500

Table 1: *GHGs and associated global warming potential (GWP).*

Factor Sets

Factor sets are created in the ClearPath™ tool to define specific or customized values for some emission sources. These may change according to reporting year data and allows for selection of the 2nd or 4th report values when setting up inventories. In this report, the 2nd Report values were chosen, because it is still common practice among Federal agencies.

The most common types of variables created are for fuel economy and emissions rates for on-road transportation, grid electricity emission factors and waste characterization data.

Several factor sets are needed for the on-road transportation calculations. Vehicle fuel economy and N2O and CH4 emission values are from the Bureau of Transportation and the US GHG Inventory tables 97-103, respectively. The vehicle mix factor determines the proportion of vehicle types used in calculations. This report uses the ICLEI default values below.

Gasoline fuel	%	Diesel fuel	%
Passenger vehicles	60.6 %	Passenger vehicles	0.3 %
Light trucks (trucks, vans, SUVs)	32.4 %	Light trucks (trucks, vans, SUVs)	1.3 %
Heavy trucks	0%	Heavy trucks	5.4 %

Table 2: *Vehicle mix for on-road gasoline and diesel fuel vehicles.*

Tacoma Power, as an approved asset-controlling supplier, recently received a grid electricity factor from the California Air Resources Board of 0.0249 MT CO2e per MWh (0.0549 lbs./kWh.) This was used for the three most recent reporting years and was considerably lower than estimated factors used in previous estimates.

This report uses the 2009 and 2015 Waste Characterization Studies commissioned by the City for the factor sets. These factor sets produce more specific inputs and emission outputs.

Calculators

Each ClearPath™ calculator consists of a series of input fields, software formulas and output fields. The software combines user-input values with data coming from other parts of the tool, such as Factor Sets and Global Warming Potential Sets, to produce outputs of GHG emissions in CO2e, or carbon dioxide equivalent.

Transportation Inputs

The on-road transportation estimates rely on combinations of sets of data. The Highway Performance Monitoring System (HPMS) is a Federal and State information system which includes data on pavement condition, traffic volume and capacity, roadway geometrics, and section improvement information. National Ambient Air Quality Standards (NAAQS) non-attainment areas base their travel estimates on HPMS data.

Washington State Department of Transportation tracks data items from approximately 5,500 sampled sections of roadway, representing the 83,000 miles of the state's public roads. WSDOT's HPMS provides annual estimates of county-level vehicle miles travelled (VMT). Annual Average Daily Traffic (AADT) volumes are derived from Permanent Traffic Recorder (PTR) stations and then multiplied to get a yearly total.

Our regional planning agency, the Puget Sound Regional Council, utilizes a travel demand model (TDM), which factors demand based on population and employment estimates at the zonal level, as well as trip generation rates from household surveys taken every 5-10 years. The model is currently using trip generation rates from the 2006 survey.

PSRC provided the VMT inputs for this GHG inventory, using their 2014 Traffic Demand Model and factoring up to 2016 estimates using the Pierce County HPMS annual increases. VMT on highways within the boundaries of the city limits are included.

Appendix B: Other Types of Greenhouse Gas Inventories

Most "conventional" GHG inventories are geographically based, analyzing estimated emissions by looking at sources of estimated emissions via various sectors (transportation, buildings, solid waste, etc.) within the physical boundary of a community. Even with detailed measurements and adjustments, conventional inventories can be limited in their ability to measure Tacoma's true carbon footprint.

However, there are other methods that can allow us to look at GHG estimated emissions from another lens, and supplement conventional inventories so we can gain a clearer picture of accurate estimated emissions. These other methods of measurement are called "consumption -based inventories" and they account for the whole life-cycle of materials, sometimes called a systems approach. Estimated emissions associated with consumption come from the production, transport, sale, use and disposal of goods (including food) and services. These kinds of inventories can help us to not just look at Tacoma as a geographical source of estimated emissions, but at how our community contributes to estimated emissions globally through our actions as consumers as well.

Consumption-based GHG inventories

A life-cycle approach to calculating GHG estimated emissions evaluates emissions associated with the consumption of a product or service at all stages of its life: raw materials extraction, manufacturing or processing, transportation, use, and end of life management. Greenhouse gases are produced throughout the lifecycle of all materials, from initial stages of production to their final disposal. Conventional inventories, however, provide an incomplete picture by only taking into account the estimated emissions produce by activities that occur within the physical boundaries of a community. This leaves out estimated emissions from materials that are used, but not produced, within the community. It is important to recognize that this conventional approach results in misinformation and causes us to ignore the responsibilities that come with overlooked emissions.

To avoid this problem we can expand our view of the estimated emissions from individual sectors to a life-cycle viewpoint. Shifting to a life-cycle viewpoint that includes prevention of waste "upstream" is important since that is often where much of the emissions reduction potential lies. This challenges the common idea that the only way to prevent emissions related to waste is to reduce materials that are disposed of through recycling or composting (which only deals with the end of a product's life).

For example, when measuring the estimated emissions that come from pair of shoes, conventional inventories would only include the emissions from the production of the shoes if they were made locally. If someone in Tacoma purchased shoes, all of the estimated emissions that came from their production would not be included in Tacoma's inventory. This means the extraction of the raw materials the shoes are made of, the actual making of the shoes and the transportation involved would all be excluded. An inventory that includes a consumption-based approach, however, would include all of those estimated emissions in Tacoma's inventory. This allows consumers to be responsible for all of the estimated emissions associated with the products they consume.

Conventional GHG Inventory	Consumption-based Inventory
Traditional or Production Sector Perspective	Systems Perspective
Usually evaluates for one calendar year	Evaluates over full life-cycle
Includes estimated emissions only from goods/ services produced within geographical bounds	Includes estimated emissions produced outside of geographical bounds that are used within the area

These kinds of inventories can help us to not just look at Tacoma as a geographical source of estimated emissions, but at how our community contributes to estimated emissions globally through our actions as consumers as well.

Methods of including a life-cycle approach in a GHG inventory

Although Tacoma has not directly calculated estimated emissions from the consumption of materials, it is crucial that we acknowledge these emissions. This is important because the goods that are produced in Tacoma, which are currently measured in the conventional GHG inventory, are often very different from those that are consumed here (which are not currently measured). In the future, we would like to perform an exact consumption-based inventory but this method is very involved. Therefore, the following examples are meant to be supplemental to Tacoma's conventional GHG inventory in order to appropriately consider the issue of materials management related to GHG emissions.

Examples of methods from other communities

King County used a consumption based emissions inventory approach to quantify emissions impacts from the goods and services consumed in the county, regardless of where the emissions were produced. Final consumption-based emissions for King County in 2008 were 55 million mT CO2e, with per person emissions at 29 mTCO2e. These estimated emissions are more than double (235%) of the emissions estimated in King County's 2008 conventional GHG inventory (23.35million mT CO2e – see figure 2). Most of the difference between the conventional and consumption-based inventories is due to the fact that in King County, people consume more emissions-intensive goods (such as vehicles and food) than they produce.

Estimated emissions from personal transportation were the single greatest category of emissions (16%), which was found to be true in the conventional inventory as well. However, consumption-based emissions associated with home energy, food, goods such as furniture and electronics, and services such as health care and banking were all nearly as large as estimated emissions from transportation (13-14% each).

This inventory found that consumption-based GHG emissions associated with the production of goods and services, including materials and manufacturing, comprised more than 60 percent of all estimated emissions associated with consumption (see figure 1 below). Actual use of the goods and services represented 27% of estimated emissions. Transporting, selling, and disposing goods and services together made up the rest at less than 15 percent of consumption-based estimated emissions.

Assuming King County and the City of Tacoma have similar demographics and purchasing behavior, we can adjust for population and estimate that Tacoma's consumption-based estimated emissions are approximately 5.96 million MT CO2e.

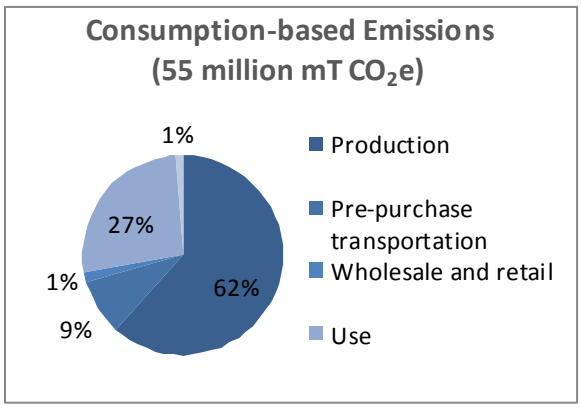


Figure 1. Percentage of estimated emissions by phase – King County Consumption-Based Emissions in 2008.

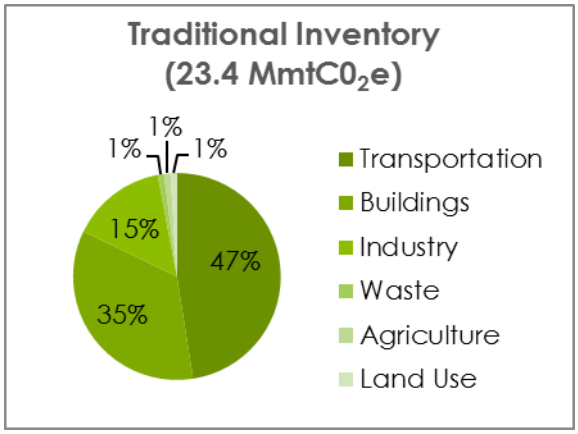


Figure 2. Percentage of estimated emissions by sector -- King County Geographic-plus Emissions in 2008.

Per-capita Method

This method involves using national per capita estimated emissions that have been derived from the EPA's "systems" inventory and multiplying these emissions by the community's population. It is important to note that because this method scales down national data to a local level, these numbers are only estimates.

Metro, the elected regional government for the Portland metropolitan area, developed a regional GHG inventory in the spring of 2010 that reported materials (goods and food) as the largest emissions source at 48 percent of all estimated emissions, at 14.9 MMT CO2e. This was calculated by adjusting national data rather than collecting direct regional measurements. This may not be exact, but since Portland's material consumption is similar to national averages, this per-capita method shows that materials management is just as important as transportation or energy in emissions reduction.

Within the materials portion, "goods" (25 %) and "food" (14 %) include the life cycle GHG estimated emissions of items such as clothing, furniture, cars, food and beverages. It also includes packaging of products and single-use items that are quickly moved to the waste stream. Also included in this section is the moving of goods and food (7 %) from distant United States' production sites to the Portland metropolitan area.

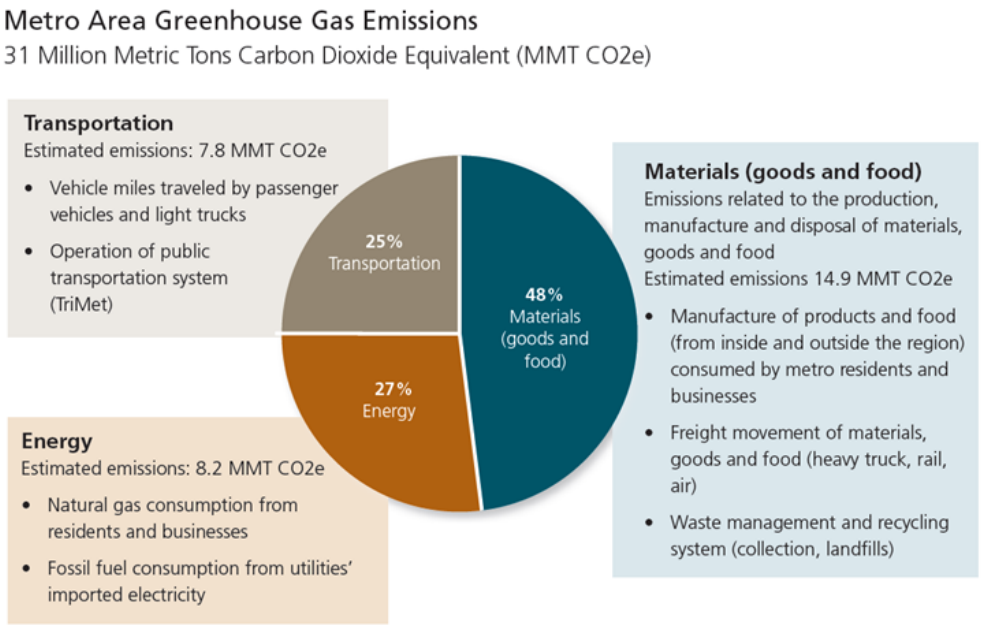


Figure 3. *Portland Metro's Regional Greenhouse Gas Inventory.*

The EPA's 2006 estimated per capita estimated emissions for materials management – provision of goods and food - was 10 MT, which is 42% of the total estimated per capita emissions.

To get a rough baseline of Tacoma's life-cycle estimated emissions associated with materials management, we can multiply Tacoma's population of approximately 200,000 by 10 to find that estimated emissions related to materials equals 2 million MT CO2e.

Conclusion

These other methods are not meant to replace conventional geographic GHG inventories, but to complement them. Both approaches are valid ways to account for a community's estimated emissions, and both are useful for various types of decision-making by citizens, government and businesses. However, these consumption-based methods give us a more complete picture of Tacoma's possible GHG estimated emissions than conventional methods alone, and may help us to identify new opportunities for emissions reduction in future.

References

King County: http://your.kingcounty.gov/dnrp/library/dnrp-directors-office/climate/2008-emissions-inventory/appendix-d.pdf

Portland Metro: http://library.oregonmetro.gov/files//regional_greenhouse_gas_inventory.pdf

Appendix C: Community Emissions Output Table (MTCDe)

	2005	% of total	2012	% of total	2016	% of Comm. total	% of City total
Buildings/Energy	**514,862**	**40%**	**579,539**	**43%**	**270,050**	**25%**	**23%**
Residential	**159,482**	**12%**	**150,318**	**11%**	**132,823**	**12.1%**	
Electricity	22,156	1.7%	23,854	1.8%	22,051	1.6%	
Natural Gas	137,326	10.7%	126,464	9.3%	110,772	8.1%	
Commercial	**117,744**	**9%**	**114,985**	**8%**	**87,386**	**7.9%**	
Electricity	4,831	0.4%	4,981	0.4%	5,501		
Natural Gas	112,913	8.8%	110,004	8.1%	81,885		
Industrial	**237,636**	**19%**	**314,236**	**23%**	**49,841**	**4.5%**	
Electricity	39,616	3.1%	36,240	2.7%	39,844		
Natural Gas	198,020	15.4%	277,996	20.4%	9,997		
Transportation	**720,729**	**56%**	**741,820**	**55%**	**785,624**	**71.3%**	**67%**
On-Road	**694,946**		**713,286**		**759,421**		
Gasoline	559,211	43.6%	556,389	40.9%	589,189	43.3%	
Diesel	135,735	10.6%	156,897	11.5%	170,232	12.5%	
Pierce Transit	**25,783**	1.9%	**28,534**	2.1%	**26,203**	1.9%	
Pierce Transit CNG	19,235	0.0%	9,393	0.7%	9,151		
Pierce Transit Diesel	5,229	0.4%	1,700	0.1%	2,161		
PT Shuttles/Vans Gasoline	1,319	0.1%	17,441	1.3%	14,891		
Solid Waste	**46,907**	**4%**	**38,146**	**3%**	**45,437**	**4.1%**	**4%**
Landfilled	46,907	3.7%	38,146	2.8%	45,437		
Totals	**1,282,498**		**1,359,505**		**1,101,111**		**94%**
City Population	198,100		202,010		207,948		
Per resident	**6.47**		**6.73**		**5.30**		
Total Households	78,806		74,723		81,811		
Per household	**16.27**		**18.19**		**13.46**		

Appendix D: Government Operations Emissions Output Table (MTCDe)

	2005	% of total	2012	% of total	2016	% of G'Ops	% of City
Buildings/Facility Energy	**1,797**	**3%**	**2,263**	**3%**	**1,962**	**3%**	**0.17%**
Combined or GG Electricity	1,011	1.5%	946	1.3%	504		
TPU Electricity					456		
Natural Gas	786	1.1%	1,317	1.8%	1,002		
Transportation	**66,273**	**96%**	**69,114**	**95%**	**69,341**	**96%**	**5.91%**
Fleet	**21,912**	32%	**18,576**	26%	**18,380**	25%	
TPU Gasoline	3,945		2,727		2,333		
GG Gasoline (gal)	3,421	4.9%	4,228	5.8%	3,688		
TPU B100 (2005), B20	240	0.3%	947	1.3%	563		
GG B100 (2005), B20	901		4,015		2,112		
TPU Diesel	1,474		1,043		1,516		
GG Diesel	6,172		1,880		4,455		
TPU Propane	0		2		4		
Solid Waste CNG	0		0		464		
Tacoma Rail	5,759	8.3%	3,734	5.1%	3,810		
Narrows Airport	0	0.0%	0	0.0%	0		
Employee Commute	**44,361**	64%	**50,538**	70%	**50,961**	70%	
SOV	38,323	55.2%	44,193	60.9%	45,036	62.1%	
Carpool	3,150	4.5%	3,258	4.5%	2,998	4.1%	
Vanpool	2,888	4.2%	3,087	4.3%	2,927	4.0%	
Streetlights/Signals	**570**	**1%**	**498**	**1%**	**547**	**1%**	**0.05%**
Streetlights & Signals	570	0.8%	498	0.7%	547		
WWT & Water Supply	**741**	**1%**	**663**	**1%**	**636**	**0.88%**	**0.05%**
WW treatment Elec.	600	0.9%	573	0.8%	564	0.8%	
WW Treatment NG	3		3		4		
Water supply Elec.	138	0.2%	87	0.1%	68	0.1%	
BioGas from Digester to Boiler	0.04	0%	0.04	0%	0.04	0.000%	
BioGas from CTPBoiler to Flare	0.25	0%	0.25	0%	0.25	0.007%	
Solid Waste	**0.04**	**0%**	**0.04**	**0%**	**0.04**	**0%**	**0.00%**
Methane Flaring	0.036	0.0%	0.04	0.0%	0.04		
Totals	**69,381**		**72,538**		**72,486**		**6%**
# of Employees	3,777		3,203		3,500		
Per Employee	**18.37**		**22.65**		**20.71**		

Appendix E: ClearPath™ Community Calculators, Data Types and Sources

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*The ClearPath calculators were created by ICLEI to compute according to the US Community Protocol, V1.1, July 2013, unless otherwise noted.

Inventory Tab 1: Residential Energy

	Calculator	Reporting Framework	Emission Source	Data Input Types	Data Contacts/Sources
1	Emissions from **Grid Electricity** **Method BE.2.1**	**Activity**	Emissions from use of **electricity** in **residential** units	TPU **kWh and Factor Set** of TPU emissions factor for period	**Keil Drescher/TPU** kdrescher@ci.tacoma.wa.us **Erika Tucci/TPU** etucci@ci.tacoma.wa.us
2	Emissions from **Stationary Fuel Combustion** **Method BE.1.1**	**Both Source and Activity**	Stationary combustion of **natural gas**, **fuel oil, propane/LPG, and wood** in residential units If you have specific point source records, which do not represent typical building activities, use a calculator for "point sources".	**Therms** provided by **PSE** **Fuel oil, propane/LPG, and wood** by unit types – gallons, cords, etc.	**Patti McClements/PSE** patricia.mcclements@pse.com Not used in 2016. Census has number of housing units in community, not consumption data.

Inventory Tab 2: Commercial Energy

	Calculator	Reporting Framework	Emission Source	Data Input Types	Data Contacts/Sources
1	Emissions from Grid Electricity **Method BE.2.1**	**Activity**	Emissions from use of **electricity** in **commercial units**	**TPU kWh and Factor Set** of TPU emissions factor for period	**Keil Drescher/TPU** kdrescher@ci.tacoma.wa.us **Erika Tucci/TPU** etucci@ci.tacoma.wa.us
2	Emissions from **Stationary Fuel Combustion Method BE.1.1**	**Both Source and Activity**	Stationary combustion of **natural gas** If you have specific point source records, which do not represent typical building activities, use a calculator for "point sources".	**Therms** provided by **PSE**	**Patti McClements/PSE** patricia.mcclements@pse.com
3	**Commercial Point Source** Emissions from **Stationary Fuel Combustion**	**Source**	Stationary combustion that represents a **Source only and not typical building energy activities such as heating and cooling**, unless this represents a district energy facility of some kind.	Not applicable.	Not applicable.

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

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Inventory Tab 3: Industrial Energy					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contacts/Sources**
1	Emissions from **Grid Electricity** **Method BE.2.1**	**Activity**	Emissions from use of **electricity** in **industrial units**	TPU **kWh and Factor Set** of TPU emissions factor for period	**Keil Drescher/TPU** kdrescher@ci.tacoma.wa.us **Erika Tucci/TPU** etucci@ci.tacoma.wa.us
2	Emissions from **Stationary Fuel Combustion** **Method BE.1.1**	**Both Source and Activity**	Stationary combustion of **natural gas** If you have specific point source records, which do not represent typical building activities, use a calculator for "point sources".	Therms provided by **PSE**	**Patti McClements/PSE** patricia.mcclements@pse.com
3	Emissions from **Stationary Fuel Combustion at Energy Industries**	**Source**	Use this calculator to account for in-jurisdiction Steam Plants, Electric Power Plants, District Cooling Plants, Combined Heat and Power (CHP), and Combined Cooling Heating and Power (CCHP) facilities.	Not used in 2016.	Not used in 2016.
4	**Industrial Point Source** Emissions from **Stationary Fuel Combustion**	**Source**	Stationary combustion that represents a **Source only and not typical building energy activities such as heating and cooling**, unless this represents a district energy facility of some kind.	Not used in 2016.	Not used in 2016.
5	**Industrial Point Source** Emissions from **Stationary Fuel Combustion**	**Source**	To accept records of previously calculated greenhouse gas emissions obtained from an external source such as a state or federal agency or other emissions registry. Use this calculator to record combustion emissions from a point source **only if you do not have the underlying data** for the quantities and types of fuels used.	Not used in 2016.	Not used in 2016.

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

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6	**Consumption of District Energy**	**Source**	There are options for consumption of heat, cooling, or electricity from such systems. **Note** that the electricity option should only be used in the case of accounting for *substantial* electricity generated by a district system that is not interconnected with the wider grid and has a unique emissions intensity and that any clean energy attributes have not been transferred outside of the district system.	Must have specific emissions factors for the energy product generated by the district energy system operator. May optionally break out Scope 3 transmission and distribution losses; though ensure that emissions factors do not factor in those losses if you do.	Not applicable.
7	**Notation Key Records for Energy Industries and Non-Specified Sources**	**Source**	Use this calculator to create simple Notation Key Records for Energy Industries by selecting the appropriate GPC Reference Number.	Not used in 2016.	Not used in 2016.

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*The ClearPath calculators were created by ICLEI to compute according to the US Community Protocol, V1.1, July 2013, unless otherwise noted.

Inventory Tab 4: Transportation and Mobile Sources					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contacts/Sources**
1	**On Road Transportation**	**Activity**	**Community on-road vehicles** (gasoline and diesel)	Select **VMT & MPG** calculator method in tool. Daily VMT estimate multiplied by 365 for annual VMT, and ICLEI **default vehicle mix. Factor Set of national MPG and emissions by vehicle type**.	**Kris Overby/PSRC** for daily VMT estimate
2	**Public Transit** Community Protocol methods **TR.4.a, TR.4.b, and TR.4.c**	**Activity**	**Public Transit**	**Not all inputs required to complete a calculation.** CH4 and N2O calculations for Gasoline and Diesel vehicles reference separate Factor Sets. Select VMT & MPG calculation method and enter fuel quantities and vehicle mix. **Factor Set of national MPG and emissions by vehicle type.**	**Peter Stackpole et al/Pierce Transit**

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*The ClearPath calculators were created by ICLEI to compute according to the US Community Protocol, V1.1, July 2013, unless otherwise noted.

3	**Aviation Travel** Refer to **GPC section 7.6** for estimation methods you may need to use to develop the inputs for this calculator.	**Activity**	**Aviation Travel**	Record transportation activities using a simple fuel use and emissions factor based approach. Create individual records to account for in-boundary and transboundary activities separately.	Not used in 2016.
4	**Rail Transportation** Refer to **GPC section 7.4** for estimation methods you may need to use to develop the inputs for this calculator.	**Activity**	**Rail Transportation**	Record transportation activities using a simple fuel use and emissions factor based approach. Create individual records to account for in-boundary and transboundary activities separately.	Not used in 2016.
5	**Off-road vehicles** Refer to the Local Government Operations Protocol, Section 7.2 for more information on this category.	**Activity**	**Off-road vehicles**	To compute emissions from the use of off-road mobile sources, such as construction, agricultural and recreational vehicles; based on fuel use.	Not used in 2016.

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*The ClearPath calculators were created by ICLEI to compute according to the US Community Protocol, V1.1, July 2013, unless otherwise noted.

6	**Water Transportation** Refer to **GPC section 7.5** for instruction on estimation methods you may need to use to develop the inputs for this calculator.	**Activity**	**Water Transportation**	Record transportation activities using a simple fuel use and emissions factor based approach. Create individual records to account for in-boundary and transboundary activities separately.	Not used in 2016.
7	**Notation Key Records** for Transportation	NA	NA	Create simple **Notation Key Records for Energy Industries** by selecting the appropriate **GPC** Reference Number.	Not used in 2016.
Inventory Tab 5: Water and Waste Water (10 calculators for jurisdictions that do not have these facilities.)					
Inventory Tab 6: Agriculture (3 calculators for jurisdictions where this is applicable)					

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*The ClearPath calculators were created by ICLEI to compute according to the US Community Protocol, V1.1, July 2013, unless otherwise noted.

Inventory Tab 7: Solid Waste					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contacts/Sources**
1	**Waste Generation**	Activity	Emissions from **community-generated waste sent to landfills**	Total tonnage sent to landfill with Factor Set of percentages of GHG-producing waste. (Ideally from Waste Characterization Studies.)	**2009 and 2015** Waste Characterization Studies. Total tonnage from **Shane Pettit/SWM** shane.pettit@cityoftacoma.org
2	**In-jurisdiction Landfills**	Source	To compute emissions from an in-jurisdiction landfill source. You will need to have determined the quantity of CH4 emitted by the landfill outside of this tool, though either a continuous emissions monitoring system or first-order decay model before using this method.	Amount of methane captured by the landfill gas capture system.	Solid Waste annual reports to state ECY. **Phet Sinthavong/SWM**
3	**Process Emissions** Associated with Landfilling Community Protocol method SW.5.	Activity	**Process Emissions --** Associated with powering equipment necessary to run/manage the landfill. **Danger of double-count of in-boundary process emissions** but could use as an indicator or for informational purposes. Comm,-generated waste process emissions should be calculated for waste delivered to landfills outside boundaries.	Not used in 2016.	Not used in 2016.

2016 Community GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*The ClearPath calculators were created by ICLEI to compute according to the US Community Protocol, V1.1, July 2013, unless otherwise noted.

4	**Collection and Transportation Emissions** Community Protocol method SW.6.	Activity	**Collection and transportation Emissions** -- Associated with collecting and transporting *outside of boundary*. **Collection emissions may be double-counted**, but could use as an indicator or for informational purposes. Transportation emissions should be calculated for waste delivered to landfills outside boundaries.	Not used in 2016.	Not used in 2016.
5	**Combustion of Solid Waste generated by the Community** Community Protocol Method SW2.2a	Activity	This calculator is designed to calculate emissions solid waste generated by the community at combustion facilities regardless of their location. A separate record should be Source/Scope 1 emissions if the combustion facility is located within the community. Use the calculator for "In-Boundary Combustion of Solid Waste" to record those records.	You may use this calculator by either entering emissions directly or calculating them according to Community Protocol Method SW2.2a.	Not applicable.
6	**Biologic Treatment of Solid Waste (Composting)**	Activity	Description not available at time of entry.	Not used in 2016.	Not used in 2016.
Inventory Tab 8: Process and Fugitive Emissions (Not utilized in 2016. 5 calculators)					
Inventory Tab 9: Upstream Impacts of Activities (Not utilized in 2016. 4 calculators)					
Inventory Tab 10: Consumption Based (Not utilized in 2016. For entering external source data.)					

Appendix F: ClearPath™ Government Operations Calculators, Data Types and Source

2016 Govt. Operations GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*ClearPath calculators were designed by ICLEI to compute according to the Local Government Operations Protocol, V1.1, May 2010, unless otherwise noted.

Inventory Tab 1: Buildings and Facilities					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contact/Source**
1	Emissions from **Grid Electricity**	**Scope 2**	Emissions from use of **electricity** in Government buildings and facilities	TPU **kWh** and **Factor Set** of **TPU emissions factor** for period	**Keil Drescher/TPU** kdrescher@ci.tacoma.wa.us **Erika Tucci/TPU** etucci@ci.tacoma.wa.us
2	Emissions from **Stationary Fuel Combustion** Recommended Approach in the **LGOP, Section 6.1.1**	**Scope 1**	Stationary combustion of **natural gas** in Government buildings and facilities	Therms provided by **PSE**, cross-checked with Portfolio Mgr. data for COT buildings	**Patti McClements/PSE** patricia.mcclements@pse.com
Inventory Tab 2: Streetlights and Traffic Signals					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contact/Source**
1	Emissions from **Grid Electricity**	**Scope 2**	Emissions from **streetlights and signals**	TPU **kWh** and Factor Set of **TPU emissions factor** for period	**Keil Drescher/TPU** kdrescher@ci.tacoma.wa.us **Erika Tucci/TPU** etucci@ci.tacoma.wa.us

2016 Govt. Operations GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*ClearPath calculators were designed by ICLEI to compute according to the Local Government Operations Protocol, V1.1, May 2010, unless otherwise noted.

Inventory Tab 3: Vehicle Fleet					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contact/Source**
1	**Fleet vehicle** Emissions	**Scope 1**	**General Government and TPU fleet vehicles**	The total quantity of **fuel** consumed for energy and CO2 calculations, as well as **total vehicle miles** traveled for each vehicle type. The calculations will reference **Transportation Factor Sets** for gasoline and diesel records.	All fleet vehicles, including GG, TPU and Tacoma Rail from **Erika Tucci/TPU** etucci@ci.tacoma.wa.us GG vehicles fuel quantities also available from **Justin Davis/Facilities,** although the numbers varied from above.
2	Emissions from **Off Road Vehicles** **LGOP Section 7.2**	**Scope 1**	The use of **off-road mobile sources, such as construction, agricultural, and recreational type vehicles**; based on the quantity of fuel consumed. Also includes locomotive/rail operated by Gov't. (Tacoma Rail).	Choose equipment type (ships/boats, **locomotives**, agricultural, construction, snowmobiles/recreational , small utility, large utility and aircraft) fuel type and amount of fuel used.	Tacoma Rail fuel info from **Erika Tucci/TPU** etucci@ci.tacoma.wa.us
Inventory Tab 4: Transit Fleet – NA; City doesn't operate a transit fleet					

2016 Govt. Operations GHG Emissions Inventory
ClearPath Calculators*, Data Types and Sources

*ClearPath calculators were designed by ICLEI to compute according to the Local Government Operations Protocol, V1.1, May 2010, unless otherwise noted.

Inventory Tab 5: Employee Commute					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contact/Source**
1	**Employee Commute**	**Scope 3**	**Employee commute vehicles**	Total employee VMT and the average fuel economy and emissions rates of their vehicles (SOV, carpool, and vanpool) as specified in the Transportation Factor Sets.	Federal Commute Trip Reduction (CTR) survey data: Meredith Soniat Active Transportation Coordinator MSoniat@ci.tacoma.wa
2	**Employee Transit Use** For employee commute using transit *in addition to* SOV. It utilizes default emissions factors from **USEPA Climate Leaders** for the different modes available. May use custom factors.	**Scope 3**	**Employee Transit Use**	Not used in 2016	Not used in 2016
3	**Employee Air Travel** Default emissions factors are taken from **USEPA Climate Leaders**	**Scope 3**	**Employee Air Travel**	Not used in 2016	Not used in 2016

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	Emissions Factors reference sheet for passenger miles in short, medium, and long haul flights. Total passenger miles need to be attributed to these classes if possible. May use custom emissions factors.				
Inventory Tab 6: Electric Power Production – NA; for purchased electricity					
Inventory Tab 7: Solid Waste Facilities					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contact/Source**
1	**Government Owned/operated Landfill**	Scope 1	Direct emissions from an in-jurisdiction landfill.	To report direct emissions from an in-jurisdiction landfill. These emissions should either have been modeled externally using First Order Decay, obtained from a continuous emissions monitoring system, or obtained from another emissions reporting program that covers the landfill in question.	Not Applicable; used calculator #7 for flaring of methane.

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2	**Waste Generation** The calculations proceed according to **Equation SW.4.1 of the Community Protocol**.	Scope 3	Downstream landfill emissions from landfill destined waste generated through your **government operations**.	The calculation references a **Waste Characterization Factor Set** that you create. Total mass for each waste type is then multiplied by the total gross methane emissions that will be generated in the landfill that will occur in the future, attributing them all to this Inventory Year.	Not used in 2016 – all waste generation is in Community track.
3	**Emissions from Grid Electricity**	Scope 1	Emissions from use of **electricity** in City solid waste treatment facilities	TPU kWh and Factor Set of TPU emissions factor for period	Reflected in overall Govt. Ops usage
4	Emissions from **Electric Power Transmission and Distribution Losses**	Scope 2	Electric Transmission and Distribution Losses from **purchased electricity** used in government operations.	This calculator computes emissions from Electric Transmission and Distribution Losses from **purchased electricity** used in government operations. It is designed to accept total purchased electricity and a grid loss factor to compute the quantity of electricity that was lost in transmission and distribution.	Not used in 2016

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5	Emissions from **Stationary Fuel Combustion** Recommended Approach in the **LGOP, Section 6.1.1** You may want to create separate records for building energy and process energy.	Scope 1	Stationary combustion of **natural gas** in Solid Waste Management facilities	Therms provided by **PSE**, cross-checked with Portfolio Mgr. data for COT buildings	Not used in 2016 – included in General Govt Operations PSE/natural gas use.
6	Emissions from **Combustion of Landfill Gas**	Scope 1	Emissions from the **combustion of Landfill Gas in a controlled device, such as a boiler or generator** used to recover useful energy. **Note** that the calculation for this source uses methods consistent with the **Community Protocol**, rather than the Local Government Operations Protocol as full combustion emissions, including N2O emissions better reflect the process than methods estimating incomplete combustion.		Not Applicable

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7	Emissions from **Combustion of Landfill Gas by Flaring** Modified equations 9.1 of the Local Government Operations Protocol. The modification addresses **only the emissions associated with the flaring device.**	Scope 1	This calculator will compute emissions that result from the incomplete combustion of Landfill Gas from an open flare. **Does not address methane leakage/incomplete collection of landfill gas from the collection system.** For estimating uncollected landfill gas, please create a separate record in the Government Owned and Operated calculator.	Methane emissions as measured by the landfill gas capture system. This is reported annually to ECY.	Phet Sinthavong/SWM psinthavong@ci.tacoma.wa.us

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Inventory Tab 8: Water and Wastewater Treatment Facilities					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contact/Source**
1	**Nitrification/Denitrification Process N_2O Emissions from Wastewater Treatment** Calculates N2O emissions from centralized wastewater treatment facilities and covers both cases of whether the facility does or does not employ Nitrification/Denitrification according to **Equations 10.7** and **10.8** of **the LGOP**.	Scope 1	Nitrification/Denitrification Process N2O Emissions from Wastewater Treatment	Not used in 2016.	Not used in 2016.
2	**Stationary Fuel Combustion** This calculator will compute emissions from stationary combustion according to the Recommended Approach in the **Local Government Operations Protocol**, Section 6.1.1. You may want to create separate records for building energy and process energy.	Scope 1	Stationary combustion of fuels in Water Production and Wastewater Treatment facilities	Not used in 2016.	Not used in 2016.
3	**N_2O emissions** from **effluent discharge to rivers and estuaries**.	Scope 1	Process N2O from Effluent	Not used in 2016.	Not used in 2016.

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	You may use this calculator for either condition whether you know the total rate of discharge or if you will use a population based method, according to **Equations 10.9 or 10.10 of the LGOP.**		Discharge to Rivers and Estuaries		
4	**Grid Electricity**	Scope 1	Use of **electricity** in City waste water treatment and water division facilities	kWh and Factor Set of TPU emissions factor for period	**Keil Drescher/TPU** kdrescher@ci.tacoma.wa.us **Erika Tucci/TPU** etucci@ci.tacoma.wa.us
5	Emissions from **purchased Electric Power Transmission and Distribution Losses**	Scope 2	Electric Transmission and Distribution Losses from **purchased electricity** used in government operations.	Total purchased electricity and a grid loss factor.	Not applicable – for purchased electricity.
6	**Process Emissions from Wastewater Treatment Lagoons** Compute process emissions from wastewater treatment lagoons according to equations WW.6 or WW.6 (alt) of the Community Protocol, depending on whether site specific BOD5 loading rates are known.	Scope 1		If using the population based method, a BOD5 generation rate of 0.09 kg/person/day is used. For either method, a maximum methane generation potential of 0.6 kg CH4/kg BOD5 and a correction factor of 0.8 are used.	Not used in 2016.

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7	**Fugitive Emissions from Septic Systems** Computes methane emissions from portions of your community utilizing individual septic systems for wastewater treatment. Uses equations 10.5 or 10.6 of the LGOP, depending on whether or not specific BOD5 loading rates are known.	Scope 1		For the population based method, a generation rate of 0.09 kg BOD5/person/day is used. For either method, a maximum generation potential of 0.6 kg CH4/kg BOD5 and a correction factor for septic systems of 0.22 are used.	Not used in 2016.
8	**Combustion of Digester Gas** according to methods **WW.1.a or WW.1.b for CH4, WW.2.a or WW.2.b for N2O and WW.3 for biogenic CO2** of the **Community Protocol**, depending on whether or not the digester gas BTU content is known. **Note** that the calculation for this source uses methods **consistent with the Community Protocol, rather than the Local Government Operations Protocol as full combustion emissions**, including N2O emissions better reflect the process than methods estimating incomplete combustion.	Scope 1	Combustion of Digester Gas	The daily standard cubic feet (SCF) of biogas produced to the boiler.	Biogas estimate was provided by **Jim Parvey** JPARVEY@ci.tacoma.wa.us Biogas production to boiler = 254,160 SCF/annually, 696 SCF daily. The gas is 57% methane.

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9	**Incomplete combustion of Digester Gas from an open flare** according to equations 10.1 or 10.2 of the Local Government Operations **Protocol** depending on whether site specific or population based methods are used.	Scope 1	Digester Gas	The daily standard cubic feet (SCF) of biogas produced to the flare.	Biogas estimate was provided by **Jim Parvey** JPARVEY@ci.tacoma.wa.us Biogas production to flare = 95,472 SCF/annually, 262 SCF daily. The gas is 57% methane. Destruction efficiency of 0.99.
10	**Methane emissions** from portions of your community utilizing **individual septic systems** for wastewater treatment. It carries out calculations according to **Equations 10.5 or 10.6 of the LGOP**, depending on whether or not specific **BOD5 loading rates are known.**	Scope 1	Individual septic systems	Not used in 2016.	Not used in 2016.
11	**Combustion of Biosolids and Sludge** Emissions from the combustion of biosolids according to Equations **WW.4** and **WW.5** of the Community Protocol for CH4 and N2O, respectively. Uses **Community Protocol Reporting Framework**	Source			Not applicable

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Inventory Tab 9: Process and Fugitive Emissions					
	Calculator	**Reporting Framework**	**Emission Source**	**Data Input Types**	**Data Contact/Source**
1	**Process and fugitive emissions** calculated externally or obtained from another data source directly.	Scope 1	Hydrofluorocarbon & Refrigerant Emissions	Not used in 2016.	Not used in 2016.
2	**Any other process and fugitive emissions calculated outside the system.** Use record name and notes to identify what type of gas this is and other information about how the original calculations were made.	Scope	Other Process and Fugitive Emissions	Not used in 2016.	Not used in 2016.