City of Tacoma
Community and Municipal
Greenhouse Gas Emissions Inventory

2012

12/18/13

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Overview

Greenhouse gas emissions in the City of Tacoma come from three primary sources: transportation fuels, the built environment, and wastewater treatment. Additionally, a smaller proportion of emissions come from solid waste sent to the landfill. Transportation fuels from on-road vehicles, including public transit, are included in the emissions estimates herein. Emissions estimates for the built environment include residential, commercial, industrial, and municipal buildings and utility services. Wastewater treatment emissions are estimated for the central treatment plants digester operations, and solid waste estimates are based on waste items sent to landfill.

Total community emissions have decreased approximately 9%, while emissions from municipal operations have increased approximately 4% since the baseline inventory year of 2000 (Table 1). Per capita community emissions estimates have also decreased approximately 12% since 2000, while per capita municipal operations emissions have increased approximately 17% (Table 2).

Table 1: Greenhouse gas emissions from community and municipal sources and activities in 2012. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE). Percent difference is relative to the 2000 baseline year. In years previous to 2012, natural gas consumption information for municipal buildings was not available. Similarly, previous to 2012 wastewater treatment values included the use of electricity in treatment facilities, in the 2012 inventory these values are incorporated into the estimate for municipal buildings.

Emission Source	2000 MTCDE	2005 MTCDE	% Diff	2012 MTCDE	% Diff
Community Emissions					
Buildings	584,901	670,997		607,024	
Transportation	1,043,458	1,288,546		881,531	
Solid Waste	30,580	37,990		25,469	
Total	1,658,939	1,997,533	+20	1,514,024	-9
Municipal Operations					
Buildings	1,038	1,480		3,277	
Fleet	22,364	32,088		26,012	
Employee Commute	5,054	5,825		7,030	
Streetlights/Signals	562	754		562	
Water/Wastewater	40,052	36,974		35,058	
Solid Waste	30	54		13	
Total	69,100	77,175	+12	71,951	+4

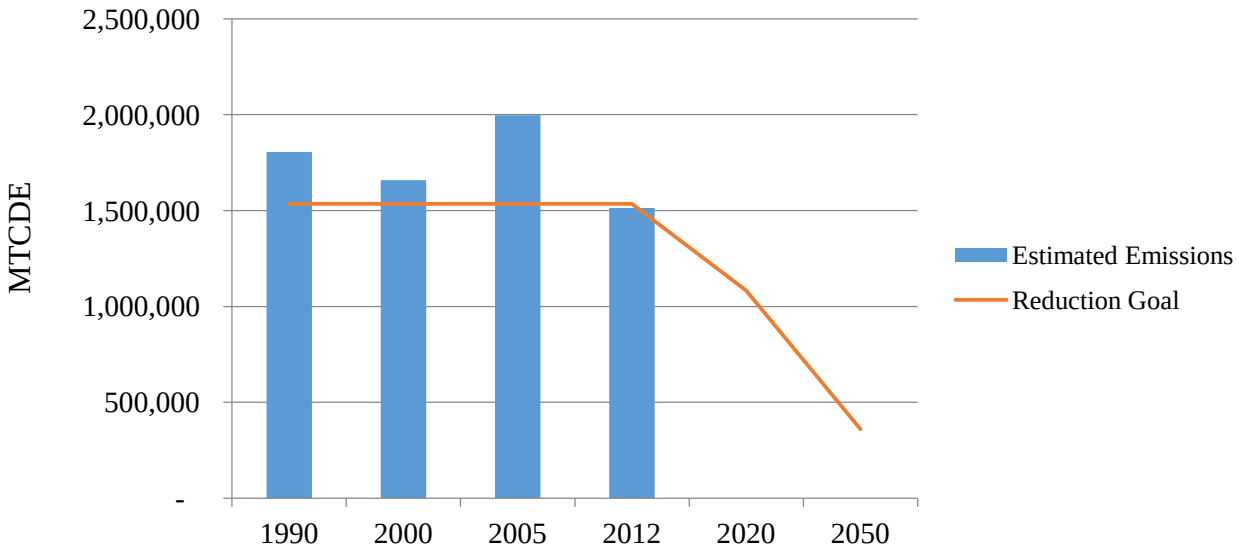
Table 2: Per capita emissions from community and municipal sources and activities in 2012. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE). Percent difference is relative to the 2000 baseline year.

Emission Source	2000 MTCDE	2005 MTCDE	% Diff	2012 MTCDE	% Diff
Per Capita Community	8.57	10.08	+17	7.49	-12
Per Capita Municipal	19.24	20.43	+4	22.46	+17

Emission Reduction Goals

In April 2005, Mayor Bill Baarsma signed the U.S. Mayors Climate Protection Agreement committing Tacoma to reduce its greenhouse gas emission levels to 7 percent below 1990 levels by 2012, the Kyoto Protocol target. However, Tacoma's Climate Action Plan developed in 2008 by the Green Ribbon Task Force calls for more aggressive reductions (Figure 1) of 15 percent below 1990 levels. Tacoma met that 2012 goal with 16 percent reduction since 1990. The Intergovernmental Panel on Climate Change states that intense efforts in the short term are better than moderate efforts over the long term. Tacoma and its citizens can and should be a leader in exceeding the Kyoto Protocol.

Figure 1: Community emission reduction goals alongside estimated emissions. 1990 emissions are modeled data only.



Emission Changes

While both community and municipal emission hit their high point in 2005, significant reductions in emissions (24% for community and 7% for municipal) have occurred between 2005 and 2012. This may be because the Climate Action Plan was not adopted until 2008 and serious efforts and awareness of this issue did not begin until then. The most significant reductions since 2005 include the community's building energy use, specifically industrial facilities natural gas use and in the community's transportation emissions, specifically from vehicle miles travelled. For municipal emissions, the most significant reductions since 2005 come from the City's sale of the airport located in Pierce County and decreases in Tacoma Rail diesel use.

Methodology

Given the many ways that communities and local governments contribute to greenhouse gas emissions and the many methodologies available to estimate emissions, the U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions (i.e., Community Protocol) and the Local Government Operations Protocol were selected as the primary guide for estimating community-wide and municipal operations emissions within the geopolitical boundary of Tacoma Washington.

The Community Protocol is a national standard developed by ICLEI-USA (International Council for Local Environmental Initiatives), now known as Local Governments for Sustainability USA. The development of the Community Protocol 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. The Community Protocol was vetted by 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 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 emissions.

Timeframe

This inventory reports greenhouse gas emissions produced between January 1, 2012 and December 31, 2012.

Data Collection

The 1990, 2000, and 2005 emission estimates were all collected and modeled at the same time in 2007 by city staff. The 2012 data was inventoried by an Evergreen graduate student. Changes in the models between the current version of the ICLEI model and the model used for the initial inventory along with the lack of clear notes for some calculations on the initial inventory and newer more complete data led to some inconsistencies between the results over the years, but we attempted to match it up as closely as possible to make comparisons between the years possible. Where feasible, we back casted from 2012 in order to base comparisons on the same protocol assumptions.

Greenhouse gases, Chemical Formulae, and Global Warming Potentials

By addressing six internationally recognized greenhouse gases regulated under the Kyoto Protocol (Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur hexafluoride (SF_6)) across five basic emission types (built environment, transportation and other mobile sources, solid waste, water and wastewater, and agriculture), the Community and Local Government Operations Protocols can be used to estimate the quantity of GHG emissions associated with community and municipal sources and activities during a chosen analysis year. For ease of reporting greenhouse gas emissions, quantities are reported in metric tons of carbon dioxide equivalents (MTCDE). Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally, and in this case, 100 years) (Table 3).

Table 3: Greenhouse gases and associated global warming potential (GWP).

Gas	Chemical Formula	Global Warming Potential

Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Hydroflourocarbons	$C_xH_yF_z$	Various
Perfluorocarbons	C_yG_y	Various
Sulfur Hexafluoride	SF_6	23,900

For the emissions factors from fossil fuels used in this report, please see the "Emission Factors for Greenhouse Gas Inventories" published by the United State Environmental Protection Agency (USEPA).

Emissions from Municipal Operations

Buildings and Facilities

The total emissions estimate for municipal buildings increased in 2012 due to the inclusion of natural gas and electricity services from Puget Sound Energy that were likely not included in previous inventories (Table 5). Additionally, wastewater treatment values included the use of electricity in treatment facilities previous to 2012, but in the 2012 inventory these values are incorporated into the estimate for municipal buildings per current protocol standards. Emissions from city-owned buildings and facilities represent roughly 5% of total emissions from municipal operations.

Table 5: Emissions from buildings and facilities operated by the City of Tacoma. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Electricity	1,038	1,480	1,872
Natural Gas	-	-	1,405
Total	1,038	1,480	3,277

Streetlights & Traffic Signals

Total emissions from electricity consumption in street lights and traffic signals have remained relatively the same since 2000 (Table 6). Increases observed in 2005 may reflect increased usage or quantity of streetlights. Decreased usage in 2012 is due to increase efficiency of the bulbs in both streetlights and signals. Streetlights and signals represent roughly 1% of total emissions from municipal operations.

Table 6: Emissions from streetlights and signals operated by the City of Tacoma. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Streetlights	538	620	538
Signals	24	134	24
Total	562	754	562

Wastewater Treatment

Emissions from wastewater treatment have been estimated in the past; however, the emissions values reported included energy consumption at the water and wastewater treatment facilities. The estimation methodology for this report incorporated energy consumption values into the community and government buildings and facilities estimates. For calendar year 2012, the values reflect emissions solely from wastewater treatment digester operations and reuse of captured biogas at the city's wastewater treatment plant (Table 7). Emissions from digester operations represent roughly 49% of total emissions from municipal operations. While the volume of biogas has remained virtually constant over time, more efficient boilers were installed at the central treatment plant in 2009.

Table 7: Emissions from wastewater treatment facilities operated by the City of Tacoma. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Wastewater	40,052	36,974	35,058

Vehicle Fleet

Emissions from the city's vehicle fleet have declined since 2005 (Table 8). Emissions from the Narrows Airport fleet that appeared in the 2000 and 2005 inventory years have reduced to zero due to sale of the property to Pierce County. Tacoma Rail has retired and replaced many old diesel engines since 2005. General government fleet emissions are relatively flat over time due to an increase in overall number of vehicles and services but those vehicles have more efficient and smaller engines. Emissions from fleet vehicles represent roughly 36% of total emissions from municipal operations.

Table 8: Emissions from fleet vehicles owned/operated by the City of Tacoma. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
General Government	7,822	9,239	9,199
Tacoma Public Utilities	8,884	12,350	13,121
Tacoma Rail	3,210	5,859	3,692
Narrows Airport	2,448	4,460	-
Total	22,364	32,088	26,012

Employee Commute

Total emissions from employee commute vehicles, estimated based on the average, round-trip employee commute distance per year, have increased since 2000 (Table 9). Single occupancy vehicle, carpool, and vanpool emissions have increased slightly since 2005 (Table 9). Emissions from employee commute vehicles represent roughly 10% of total emissions from municipal operations.

Table 9: Emissions from City of Tacoma employee commute vehicles. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Single Occupancy Vehicles	4,408	4,618	5,852
Carpool	232	314	456
Vanpool	414	894	722
Total	5,054	5,825	7,030

Waste

Emissions from solid waste sent to the landfill have decreased since 2005 (Table 10). These 2012 emission estimates are based on per person waste estimates obtained from the Tacoma Municipal Building Complex waste-stream audit completed in 2010. Emissions from solid waste represent less than 1% of total emissions from municipal operations.

Table 10: Emissions from City of Tacoma solid waste sent to landfill. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE

Solid Waste	30	54	13

Emissions from Community Sources and Activities

Transportation

Emissions from both gasoline and diesel powered on-road vehicles in the City of Tacoma have decreased from 2005 estimates (Table 11). Gasoline and diesel related emissions in on-road vehicles increased from 2000 to 2005, but have since decreased significantly. The reductions observed may be a result of decreased vehicles on the road, but may also vary from the differing estimation method employed. Emissions from public transit vehicles operating in Pierce County and serving the City of Tacoma have increased from estimates reported in 2005 (Table 12). Estimates for biodiesel were not made available for the 2012 inventory year. Emissions from transportation represent roughly 58% of total community emissions.

Table 11: On-road vehicle emissions from fuel combustion by inventory year. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Vehicle Fuel	2000 MTCDE	2005 MTCDE	2012 MTCDE
Gasoline	862,459	1,052,551	723,752
Diesel	165,820	217,248	145,958
Total	1,028,279	1,269,800	869,710

Table 12: Pierce Transit vehicle emissions from fuel combustion by inventory year. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Vehicle Fuel/Type	2000 MTCDE	2005 MTCDE	2012 MTCDE
Compressed Natural Gas	5,741	12,999	11,821
Diesel	7,341	11	1,499
B-20	-	2,312	-
Vanpool	2,097	2,770	3,095
Shuttle	-	654	4,114
Total	15,179	18,746	20,529

Buildings

Emissions from residential buildings within the City of Tacoma have decreased slightly since 2005 estimates (Table 13). Emissions from commercial buildings within the City of Tacoma

have increased slightly since 2005 estimates (Table 14). Emissions from industrial buildings within the City of Tacoma have decreased since 2005 estimates (Table 15). Emissions from buildings represent roughly 40% of community emissions.

Table 13: Emissions from residential buildings by inventory year. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Electricity	27,054	25,022	26,939
Natural Gas	129,903	133,774	126,464
Wood	123	284	645
Oil	15,687	14,334	12,816
Propane	1,577	2,397	3,231
Total	174,344	175,811	170,095

Table 14: Emissions from commercial buildings by inventory year. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Electricity	5,953	5,455	5,871
Natural Gas	100,767	104,869	110,004
Total	106,720	110,324	115,875

Table 15: Emissions from industrial buildings by inventory year. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Electricity	58,727	44,740	43,057
Natural Gas	245,111	340,122	277,996
Heavy Fuel Oil	63,737	71,155	71,155
Light Fuel Oil	-	199	199
Total	303,837	384,862	321,053

Solid Waste

Emissions from waste sent to the landfill in 2012 are lower than the estimates reported in 2000 and 2005 reflecting less tons of trash disposed with possibly less methane intense emissions (Table 16). Emissions from landfilled waste represent roughly 2% of total community emissions.

Table 16: Emissions from solid waste sent to landfill by inventory year. Values expressed in Metric Tons of Carbon Dioxide Equivalents (MTCDE).

Emission Source	2000 MTCDE	2005 MTCDE	2012 MTCDE
Solid Waste	30,580	37,990	25,469

Incorporating Materials Management in Greenhouse Gas Inventories

Most "conventional" greenhouse gas (GHG) inventories are geographically based, analyzing emissions by looking at sources of 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 greenhouse gas emissions from another lens, and supplement conventional inventories so we can gain a clearer picture of accurate 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. 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 emissions, but at how our community contributes to emissions globally through our actions as consumers as well.

Consumption-based GHG inventories

A life-cycle approach to calculating GHG 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 emissions produce by activities that occur within the physical boundaries of a community. This leaves out 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 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 (a solution that only deals with the end of a product's life).

For example, when measuring the 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 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 emissions in Tacoma's inventory. This allows consumers to be responsible for all of the emissions associated with the products they consume, whether produced locally or not.

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 emissions only from goods/services produced within geographical bounds	Includes emissions produced outside of geographical bounds that are used within the area

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

Although Tacoma has not directly calculated 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 greenhouse gas emissions.

Examples of methods from other communities:

Consumption Method

This type of inventory includes only the emissions associated with consumption of goods within a geographic area, which typically are produced all over the world.

King County used a new Consumption Based Emissions Inventory approach to quantify emissions impacts from the goods and services consumed in the King 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 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.

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 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 emissions associated with consumption (see figure 1 below). Actual use of the goods and services represented 27% of emissions. Transporting, selling, and disposing goods and services together made up the rest at less than 15 percent of consumption-based emissions.

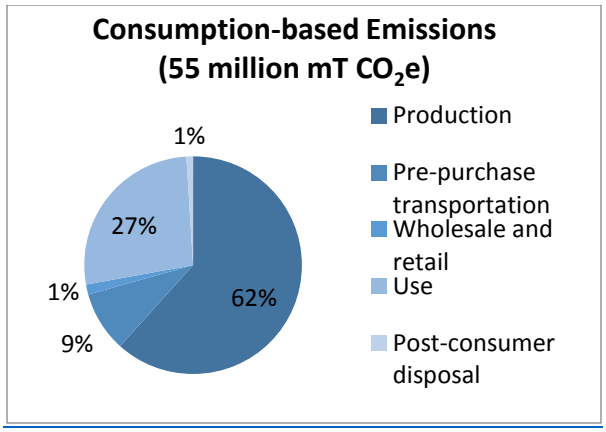


Figure 1. Percentage of emissions by phase – King County Consumption-Based Emissions in 2008.

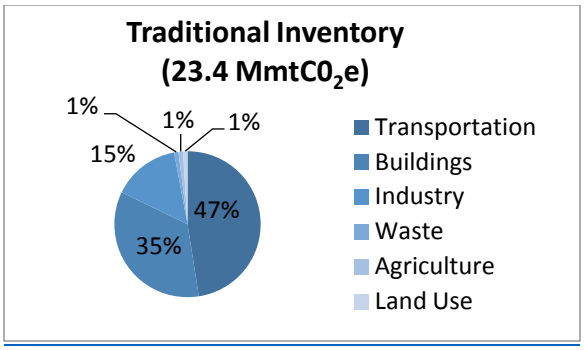


Figure 2. Percentage of emissions by sector King County Geographic-plus Emissions in 2008

Tacoma's equivalent 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 emissions are approximately 5.96 million mT CO2e.

Per-capita Method

This method involves using national per capita 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 greenhouse gas inventory in the spring of 2010 that reported materials (goods and food) as the largest emissions source at 48 percent of all 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.

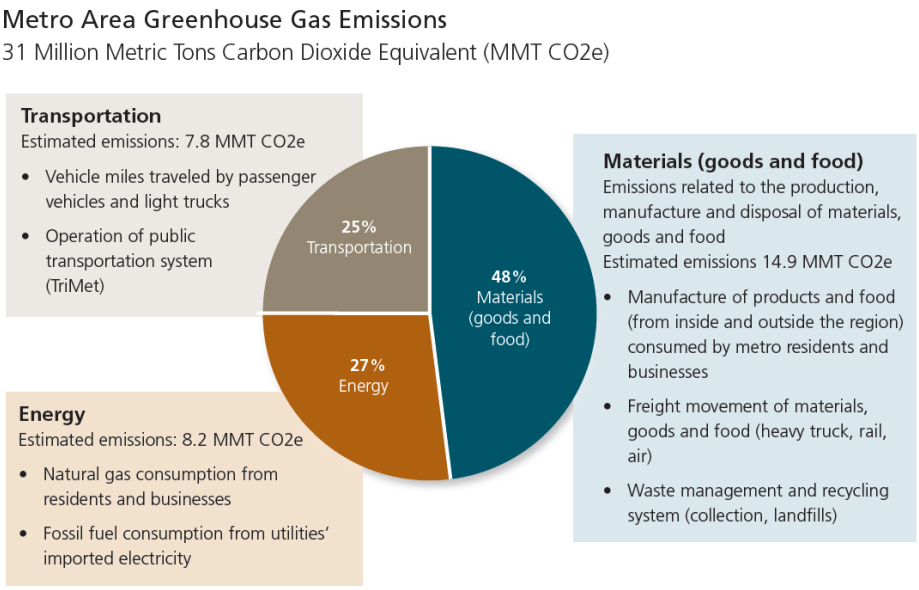


Figure 3. Metro's Regional Greenhouse Gas Inventory

Within the materials portion, "goods" (25 %) and "food" (14 %) include the life cycle greenhouse gas 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.

Tacoma's per-capita emissions: The EPA's 2006 estimated per capita 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 emissions associated with materials management, we can multiply Tacoma's population of approximately 200,000 by 10 to find that 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 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 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

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

Appendix

Table 17: List of data inputs for emissions estimates.

Emission Source or Activity	2012 Value	Units
Community Sources and Activities		
Residential Electricity	957,913	kilowatt hours
Residential Natural Gas	23,791,053	therms
Residential Wood	5,282	short tons
Residential Oil	1,248,019	gallons
Residential Propane/LPG	572,411	gallons
Commercial Electricity	208,774,857	kilowatt hours
Commercial Natural Gas	20,694,621	therms
Industrial Electricity	1,531,015,620	kilowatt hours
Industrial Natural Gas	52,380,997	therms
On-road Vehicle Traffic	1,504,822,000	vehicle miles traveled
Pierce Transit Compressed Natural Gas	1,635,612	gallons gasoline equivalent
Pierce Transit Diesel	146,676	gallons
Pierce Transit Vanpool	344,729	gallons
Pierce Transit Shuttles	428,584	gallons
Landfilled Waste	156,613	short tons
Municipal Sources and Activities		
Building Electricity	45,291,027	kilowatt hours
Building Natural Gas	264,231	therms
Fleet - General Government Diesel	184,118	gallons
Fleet – General Government Gasoline	481,510	gallons
Fleet – General Government Biodiesel	491,570	gallons
Fleet – Tacoma Public Utilities Heavy Duty Biodiesel	17,615	gallons
Fleet – Tacoma Public Utilities Light Duty Biodiesel	5,566	gallons
Fleet – Tacoma Public Utilities Heavy Duty Diesel	138,984	gallons
Fleet – Tacoma Public Utilities Light Duty Diesel	56,818	gallons
Fleet – Tacoma Public Utilities Off-Road Diesel	105	gallons
Fleet – Tacoma Public Utilities Heavy Duty Propane/LPG	4	gallons
Fleet - Tacoma Public Utilities Light Duty Propane/LPG	305	gallons
Fleet - Tacoma Rail Diesel	361,570	gallons
Employee Single Occupancy Vehicle	12,948,128	vehicle miles traveled
Employee Carpool	1,008,945	vehicle miles traveled
Employee Vanpool	1,597,496	vehicle miles traveled
Streetlights	19,113,000	kilowatt hours
Traffic Signals	860,000	kilowatt hours
Central Treatment Plant Digester Biogas	150,670,000	cubic feet
Landfilled Waste	96	short tons