# 2012 Seattle Community Greenhouse Gas Emissions Inventory

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Prepared by


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Seattle has been a leader in addressing climate change for years. Most recently, the City released its ambitious 2013 Climate Action Plan, a package of actions intended to put Seattle on a path to carbon neutrality by 2050, which is defined as zero net emissions. The Plan focuses on a set of core emissions sources where City and local community action can have the greatest impact: road transportation, building energy, and waste. The City's specific emission-reduction targets for these core sources are 58% by 2030, and 87% by 2050 below 2008 levels.

Our latest evaluation of emissions data, which tracks the period from 1990 to 2012, allows us to monitor our progress toward our goals, and it will inform Seattle's ongoing climate action planning. The results of the 2012 inventory show that total emissions in the core sectors have declined 4% from 1990 levels. But reductions in total emissions only tell part of the story and it is important to remember that between 1990 and 2012, Seattle's population and jobs grew 23% and 14% respectively, even while our emissions fell. The 2012 GHG inventory demonstrates that cities can grow in population and economic activity while still reducing emissions.

Another look at the 2012 emissions inventory on a per person basis underscores the point that on an individual level, core greenhouse gas emissions are shrinking rather significantly. Per person core emissions decreased 22% from 1990 to 2012, and 6% from 2008 to 2012. In fact, Seattle's per person core emissions have been about half the national average and a third lower than the average King County resident outside Seattle.

Seattle's climate actions are having an impact. Our buildings are greener thanks to energy efficiency investments and Seattle City Light's commitment to carbon neutrality. We are generating less waste, while recycling and composting a lot more. We're building out our bike, pedestrian, and transit systems to help people travel easily and affordably without a car. And our neighborhood village strategy has created communities where people can live, work, and play.

I am pleased that Seattle is making progress in reducing emissions, yet I also know that a bold goal like carbon neutrality pushes us to do even more. A lot of that "more" is mapped out in the 2013 Climate Action Plan, but we also need everyone in Seattle to join in to support the actions, investments, and policies that will make Seattle a climate friendly city of the future. To make sure that we're on track, the City will continue to monitor our progress through regular community greenhouse gas inventories.

Jill Simmons, Director
Seattle Office of Sustainability & Environment

# Table of Contents

# INTRODUCTION

Greenhouse gas emissions inventories are the primary means of monitoring and reporting progress toward emission-reduction goals. This 2012 GHG inventory analyzes Seattle's community emissions in 1990, 2005, 2008, and 2012. The inventory methods used here are guided by ICLEI-USA's recent U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions.

Seattle's emissions are considered from two perspectives:

- **"Core" emissions** are those which the City has the greatest opportunity to influence and are the focus of Seattle's 2013 Climate Action Plan: building energy use, road transportation, and waste management. The Plan recommends a package of actions to reduce GHG emissions in these core sectors by 58% by 2030 and 87% by 2050 from recent (2008) levels, not including offsets.
- **"Expanded" emissions** include additional sources, such as industry, marine, rail, and air travel, yard equipment, and wastewater treatment. These sources serve regional or national demands and/or are more difficult for the City to influence. While these sources are not as directly within the City's sphere of influence, Seattle remains interested in an expanded view of its GHG emissions to monitor emissions trends and identify opportunities where City actions can have an impact.

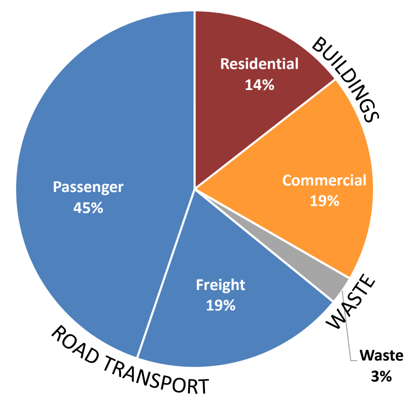
This information will not only help the City monitor its performance against its ambitious goals but will also inform ongoing climate action planning.

# GHG INVENTORY: CORE EMISSIONS

Seattle's core emissions are from the road transportation, building energy, and waste sectors. In 2012, road transportation (especially passenger travel) comprises the largest share of Seattle's core emissions at 64%. Emissions associated with building energy comprise 33%, while emissions from waste comprise 3% (Figure 1).

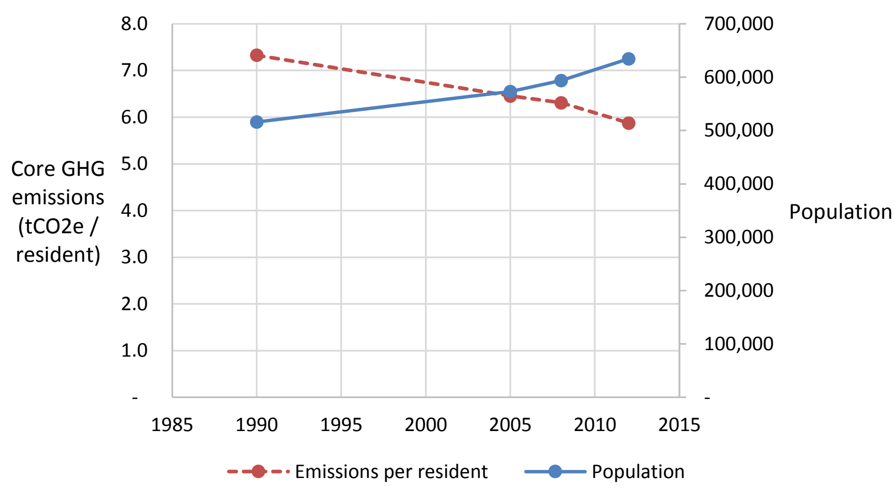
Seattle's core emissions have remained relatively flat over the four years analyzed: 1990, 2005, 2008, and 2012.[1] Accounting for offsets purchased by Seattle City Light (for the small portion of fossil fuel-based electricity in their portfolio), total core emissions have declined from approximately 3.8 million tons in 1990 to approximately 3.6 million tons in 2008 and 2012.[2]

**Figure 1. 2012 Seattle core emissions**




The 4% decline from 1990 to 2012 after accounting for offsets, though modest, is more impressive considering Seattle's population has grown 23% (118,000) and jobs have increased 14% (60,000) over the same time period. On a per person basis, Seattle's emissions declined 22% since 1990 and 6% since 2008 (Figure 2, Table 1, Table 2).

**Figure 2. Core greenhouse gas emissions per person have declined as population has increased**

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[1] Applying the ICLEI-USA method to 2012 required recalculation of certain emissions from prior years to enable evaluation of emissions trends over time. Seattle's core emissions correspond to ICLEI's "local government significant influence" framework. The expanded view of the inventory presented later corresponds to ICLEI's "community wide activities" framework.

[2] All figures are reported in metric tons.

### Table 1. Seattle core greenhouse gas emissions by sector (metric tons $CO_2e$)

| | 1990 | 2005 | 2008 | 2012 | % change 1990-2012 | % change 2008-2012 |
|---|---|---|---|---|---|---|
| **TRANSPORTATION** | **2,196,000** | **2,309,000** | **2,255,000** | **2,390,000** | **9%** | **6%** |
| **Road: Passenger** | **1,561,000** | **1,628,000** | **1,578,000** | **1,670,000** | **7%** | **6%** |
| *Cars & Light Duty Trucks* | *1,512,000* | *1,572,000* | *1,510,000* | *1,603,000* | *6%* | *6%* |
| *Buses* | *47,000* | *54,000* | *66,000* | *64,000* | *36%* | *-3%* |
| *Vanpool* | *2,000* | *2,000* | *2,000* | *2,000* | *0%* | *0%* |
| **Road: Freight** | **635,000** | **681,000** | **677,000** | **720,000** | **13%** | **6%** |
| *Trucks* | *635,000* | *681,000* | *677,000* | *720,000* | *13%* | *6%* |
| **BUILDINGS** | **1,465,000** | **1,268,000** | **1,375,000** | **1,243,000** | **-15%** | **-10%** |
| **Residential** | **721,000** | **570,000** | **608,000** | **538,000** | **-25%** | **-12%** |
| *Electricity* | *133,000* | *68,000* | *44,000* | *28,000* | *-79%* | *-36%* |
| *Natural Gas* | *259,000* | *371,000* | *432,000* | *420,000* | *62%* | *-3%* |
| *Oil* | *329,000* | *131,000* | *131,000* | *89,000* | *-73%* | *-32%* |
| **Commercial** | **744,000** | **698,000** | **767,000** | **705,000** | **-5%** | **-8%** |
| *Electricity* | *169,000* | *102,000* | *82,000* | *53,000* | *-69%* | *-35%* |
| *Natural Gas* | *281,000* | *351,000* | *401,000* | *402,000* | *43%* | *0%* |
| *Oil* | *150,000* | *84,000* | *108,000* | *93,000* | *-38%* | *-14%* |
| *Steam* | *144,000* | *160,000* | *177,000* | *156,000* | *8%* | *-12%* |
| **WASTE** | **122,000** | **124,000** | **115,000** | **95,000** | **-22%** | **-17%** |
| *Waste Management* | *122,000* | *124,000* | *115,000* | *95,000* | *-22%* | *-17%* |
| **TOTAL EMISSIONS** | **3,783,000** | **3,701,000** | **3,745,000** | **3,728,000** | **-1%** | **0%** |
| **Per person** | **7.3** | **6.5** | **6.3** | **5.9** | **-20%** | **-7%** |
| **GHG OFFSETS** | | **-170,000** | **-126,000** | **-81,000** | | |
| **City Light Offset Purchases** | | **-170,000** | **-126,000** | **-81,000** | | |
| **TOTAL AFTER OFFSETS** | **3,783,000** | **3,531,000** | **3,619,000** | **3,647,000** | **-4%** | **1%** |
| **Per person** | **7.3** | **6.2** | **6.1** | **5.7** | **-22%** | **-6%** |

### Table 2. Seattle core greenhouse gas emissions per person, by sector (metric tons $CO_2e$)[3]

| Per Person GHG Emissions by Sector | 1990 | 2005 | 2008 | 2012 | % change 1990-2012 | % change 2008-2012 |
|---|---|---|---|---|---|---|
| **TRANSPORTATION** | **4.3** | **4.0** | **3.8** | **3.8** | **-11%** | **-1%** |
| Road: Passenger | 3.0 | 2.8 | 2.7 | 2.6 | -13% | -1% |
| Road: Freight | 1.2 | 1.2 | 1.1 | 1.1 | -8% | -1% |
| **BUILDINGS** | **2.8** | **2.2** | **2.3** | **2.0** | **-31%** | **-15%** |
| Residential | 1.4 | 1.0 | 1.0 | 0.8 | -39% | -17% |
| Commercial | 1.4 | 1.2 | 1.3 | 1.1 | -23% | -14% |
| **WASTE** | **0.2** | **0.2** | **0.2** | **0.1** | **-37%** | **-23%** |
| Waste Management | 0.2 | 0.2 | 0.2 | 0.1 | -37% | -23% |
| **TOTAL PER PERSON** | **7.3** | **6.5** | **6.3** | **5.9** | **-20%** | **-7%** |
| **GHG OFFSETS** | | **-0.3** | **-0.2** | **-0.1** | | |
| City Light Offset Purchases | | -0.3 | -0.2 | -0.1 | | |
| **TOTAL AFTER OFFSETS** | **7.3** | **6.2** | **6.1** | **5.7** | **-22%** | **-6%** |

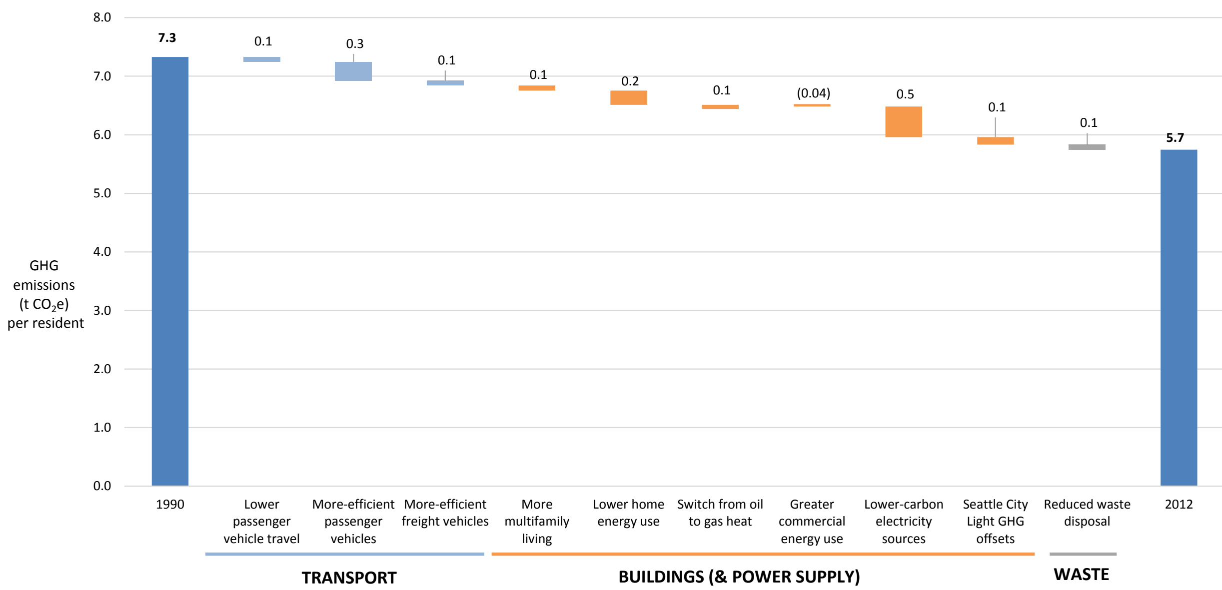
Total emissions have increased in road transportation and decreased in building energy and waste, but emissions in all sectors have decreased on a per person basis. Key changes include:

- **Emissions from road transportation have increased 9% since 1990, or 193,000 metric tons $CO_2$**, primarily due to Seattle's increasing population and economic activity and the associated increase in overall vehicle travel. **However vehicle emissions per person have declined by 11%, as residents drive cleaner cars fewer miles.**
- **Building energy emissions have decreased 15% since 1990, or 222,000 metric tons $CO_2$**, due to the continued decrease in the carbon intensity of City Light electricity, as the utility has moved away from coal (Centralia) and gas (Klamath Falls); increasing energy efficiency of Seattle's building through energy upgrades and a strong energy code; a sustained switch from oil to natural gas for home heating (especially between 1990 and 2005); and a greater share of residents living in smaller, multi-family dwellings. **Per person, building energy emissions have declined 31%.**
- **Waste emissions decreased 22% since 1990, or 27,000 metric tons $CO_2$,** due to decreased waste generation and increased recycling and composting. **Waste emissions per person declined 37%.**

[3] This table displays figures before accounting for offsets purchased by Seattle City Light.

Several factors account for the reduction in emissions per person (Figure 3). Chief among these is the move away from coal- and gas-based generation by Seattle City Light, along with the trend toward more-efficient passenger vehicles and lower home energy use. Together, these three factors account for about two-thirds of the decline in per person emissions. Other, less significant factors include lower passenger vehicle travel, more efficient freight vehicles, more multifamily living, the switch from oil to gas heat, and reduced waste disposal.

**Figure 3. Multiple factors explain the decrease in core GHG emissions per person**




Looking at emissions on a per person basis illustrates the benefits of urban form, and the value of Seattle accommodating a growing population with lower per person vehicle travel and lower-carbon electricity than in many other areas. Core emissions have been about one-third less in Seattle than in the rest of King County, and about one-half less than for the United States as a whole.[4]

[4] The comparison for King County is for 2008, based on new analysis of data published in King County's 2008 inventory *Greenhouse Gas Emissions in King County*, that indicates per person core emission in King County outside Seattle of 9.1 t $CO_2$e The comparison for the United States is 11.2 t $CO_2$e for 2012, based on the EPA's national GHG inventory for 2012, and including direct and indirect $CO_2$ associated with residential and commercial building energy use, direct $CO_2$ associated with all road vehicles, and $CH_4$ from all landfills. Since the EPA's inventory includes some vehicle trips (e.g. long distance vehicle trips) that may not be included here (due to the limitations in PSRC's travel model at estimating long distance vehicle travel that originates or ends in Seattle), the difference between Seattle's core and U.S. average emissions may be overstated.

# EXPANDED VIEW OF SEATTLE'S GHG INVENTORY

Other sources of emissions, such as air and marine travel and cement production, serve regional or national demands and are more difficult for the City to influence. While these sources are not as directly within the City's sphere of influence, Seattle remains interested in an expanded view of its GHG emissions to monitor emissions trends and identify opportunities where City actions can have an impact.

Therefore, the City has also prepared a more complete inventory that includes these other emissions sources in the community. In the expanded view – inclusive of industry, marine, rail, and air travel, yard equipment, and wastewater treatment – Seattle's emissions totaled 6.0 million tons $CO_2e$ in 2012, after accounting for GHG offsets purchased by Seattle City Light (Table 3).

The expanded view of emissions is more consistent with the approach used in 2005, when the City adopted the suggested U.S. greenhouse gas emissions target from the Kyoto Protocol of 7% below 1990 emissions by 2012. Seattle reduced GHG emissions by 1% from 1990 to 2012, falling short of the target. However, Seattle did reduce GHG emissions *per person* in the expanded view over the period by 20%.

## Table 3. Seattle community greenhouse gas emissions by sector (metric tons $CO_2e$): expanded view

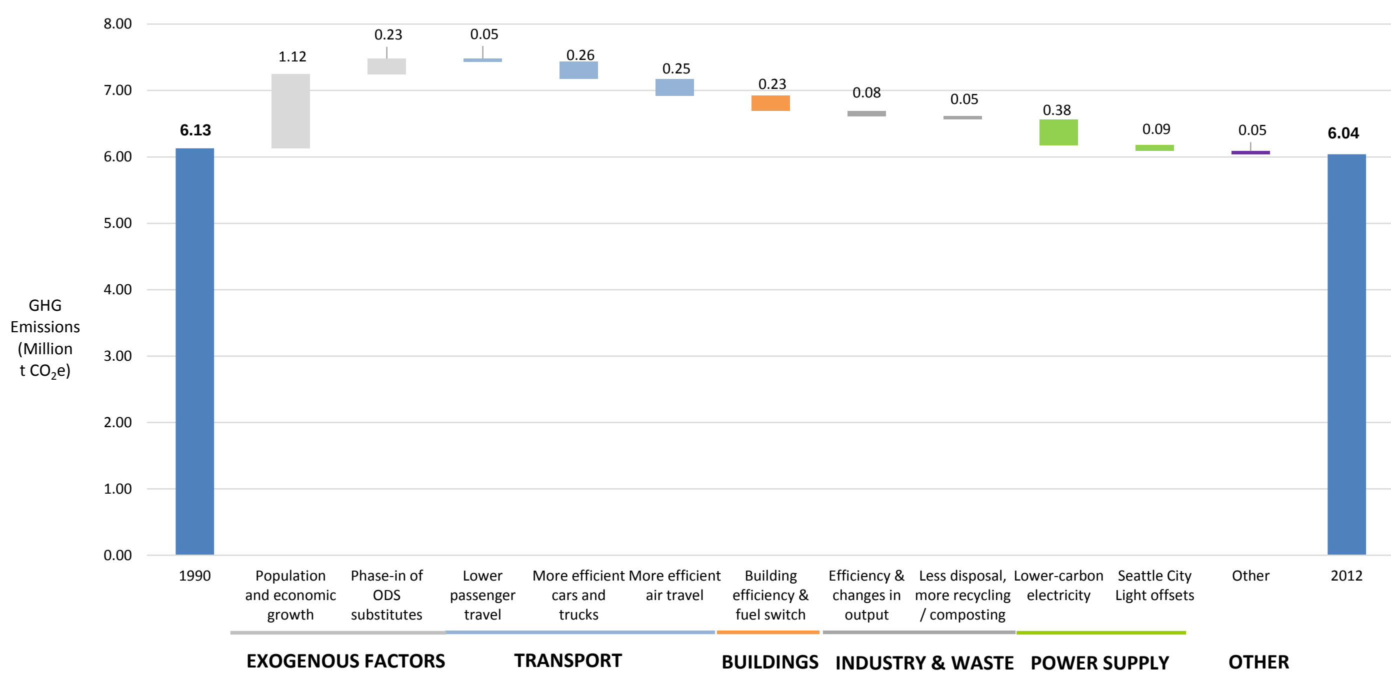
| | 1990 | 2005 | 2008 | 2012 | % change 1990-2012 | % change 2008-2012 |
|---|---|---|---|---|---|---|
| **TRANSPORTATION** | **3,412,000** | **3,487,000** | **3,524,000** | **3,542,000** | **4%** | **1%** |
| **Road: Passenger** | **1,561,000** | **1,628,000** | **1,578,000** | **1,670,000** | **7%** | **6%** |
| *Cars & Light Duty Trucks* | *1,512,000* | *1,572,000* | *1,510,000* | *1,603,000* | *6%* | *6%* |
| *Buses* | *47,000* | *54,000* | *66,000* | *64,000* | *36%* | *-3%* |
| *Vanpool* | *2,000* | *2,000* | *2,000* | *2,000* | *0%* | *0%* |
| **Road: Freight** | **635,000** | **681,000** | **677,000** | **720,000** | **13%** | **6%** |
| *Trucks* | *635,000* | *681,000* | *677,000* | *720,000* | *13%* | *6%* |
| **Marine & Rail** | **276,000** | **274,000** | **293,000** | **247,000** | **-11%** | **-16%** |
| *Hotelling* | *53,000* | *51,000* | *74,000* | *46,000* | *-13%* | *-38%* |
| *Washington State Ferries* | *41,000* | *42,000* | *35,000* | *42,000* | *2%* | *20%* |
| *Pleasure Craft* | *32,000* | *30,000* | *31,000* | *31,000* | *-3%* | *0%* |
| *Other Ship & Boat Traffic* | *65,000* | *62,000* | *64,000* | *64,000* | *-2%* | *0%* |
| *Rail - Freight* | *85,000* | *81,000* | *79,000* | *53,000* | *-38%* | *-33%* |
| *Rail - Passenger* | *1,000* | *9,000* | *10,000* | *12,000* | *1100%* | *20%* |
| **Air** | **940,000** | **904,000** | **976,000** | **905,000** | **-4%** | **-7%** |
| *Sea-Tac Airport* | *756,000* | *688,000* | *718,000* | *681,000* | *-10%* | *-5%* |
| *King County Airport* | *184,000* | *216,000* | *258,000* | *224,000* | *22%* | *-13%* |
| **BUILDINGS** | **1,620,000** | **1,430,000** | **1,545,000** | **1,424,000** | **-12%** | **-8%** |
| **Residential** | **741,000** | **587,000** | **625,000** | **557,000** | **-25%** | **-11%** |
| *Electricity* | *133,000* | *68,000* | *44,000* | *28,000* | *-79%* | *-36%* |
| *Natural Gas* | *259,000* | *371,000* | *432,000* | *420,000* | *62%* | *-3%* |
| *Oil* | *329,000* | *131,000* | *131,000* | *89,000* | *-73%* | *-32%* |
| *Yard Equipment* | *20,000* | *17,000* | *17,000* | *19,000* | *-5%* | *12%* |
| **Commercial** | **879,000** | **843,000** | **920,000** | **867,000** | **-1%** | **-6%** |
| *Electricity* | *169,000* | *102,000* | *82,000* | *53,000* | *-69%* | *-35%* |
| *Natural Gas* | *281,000* | *351,000* | *401,000* | *402,000* | *43%* | *0%* |
| *Oil* | *150,000* | *84,000* | *108,000* | *93,000* | *-38%* | *-14%* |
| *Steam* | *144,000* | *160,000* | *177,000* | *156,000* | *8%* | *-12%* |
| *Commercial Equipment* | *135,000* | *145,000* | *153,000* | *162,000* | *20%* | *6%* |
| **INDUSTRY** | **976,000** | **1,552,000** | **1,503,000** | **1,069,000** | **10%** | **-29%** |
| **Cement** | **417,000** | **861,000** | **746,000** | **307,000** | **-26%** | **-59%** |
| *Fuel Combustion* | *211,000* | *377,000* | *353,000* | - | - | - |
| *Clinker Calcination* | *206,000* | *484,000* | *393,000* | - | - | - |
| **Other - Energy Use** | **528,000** | **457,000** | **513,000** | **488,000** | **-8%** | **-5%** |
| *Electricity* | *62,000* | *26,000* | *17,000* | *10,000* | *-84%* | *-41%* |
| *Natural Gas* | *266,000* | *246,000* | *232,000* | *259,000* | *-3%* | *12%* |
| *Oil* | *49,000* | *11,000* | *36,000* | *16,000* | *-67%* | *-56%* |
| *Industrial Equipment* | *151,000* | *173,000* | *228,000* | *202,000* | *34%* | *-11%* |
| **Other - Process Emissions** | **20,000** | **37,000** | **40,000** | **39,000** | **95%** | **-3%** |
| *Steel & Glass* | *20,000* | *37,000* | *40,000* | *39,000* | *95%* | *-3%* |
| **Fugitive Gases** | **11,000** | **197,000** | **204,000** | **235,000** | **>100%** | **15%** |
| *ODS Substitutes* | *1,000* | *192,000* | *202,000* | *235,000* | *>100%* | *16%* |
| *Switchgear Insulation (SF6)* | *10,000* | *5,000* | *2,000* | *1,000* | *-90%* | *-50%* |
| **WASTE** | **123,000** | **126,000** | **117,000** | **97,000** | **-21%** | **-17%** |
| **Waste** | **123,000** | **126,000** | **117,000** | **97,000** | **-21%** | **-17%** |
| *Waste Management* | *122,000* | *124,000* | *115,000* | *95,000* | *-22%* | *-17%* |
| *Wastewater Treatment* | *2,000* | *2,000* | *2,000* | *2,000* | *0%* | *0%* |
| **TOTAL EMISSIONS** | **6,131,000** | **6,595,000** | **6,689,000** | **6,132,000** | **0%** | **-8%** |
| **Per person** | **11.9** | **11.5** | **11.3** | **9.7** | **-19%** | **-14%** |
| **GHG OFFSETS** | | **-196,000** | **-143,000** | **-91,000** | | |
| **City Light Offset Purchases** | | **-196,000** | **-143,000** | **-91,000** | | |
| **TOTAL AFTER OFFSETS** | **6,131,000** | **6,399,000** | **6,546,000** | **6,041,000** | **-1%** | **-8%** |
| **Per person** | **11.9** | **11.2** | **11.0** | **9.5** | **-20%** | **-14%** |

The very small change in total emissions between 1990 and 2012 masks a number of factors that led to emissions increases and decreases – factors that, in sum, almost exactly canceled each other out (Figure 4).

Population and economic growth led to increases in vehicle travel, building energy use, and waste generation, which, had they not been counteracted by efficiency and other improvements, would have increased Seattle's emissions by over 1 million metric tons $CO_2e$. The introduction of a new class of refrigerants also accounts an emissions increase – 230,000 tons $CO_2e$, as hydrofluorocarbons replaced the prior class of ozone-depleting refrigerants (e.g., CFCs) that were phased out after 1990. Both types of refrigerants have climate impacts; however, national and local government GHG inventory accounting protocols do not include the gases that were phased out (under the Montreal Protocol), only the replacement gases.[5]

A number of factors led to emissions decreases that counteracted the effect of population and economic growth, especially (as already noted) the decrease in carbon intensity of Seattle City Light's electricity, more efficient cars and trucks, and building efficiency (including smaller dwellings) and fuel switching. Increased efficiency of air travel also contributed to a decrease in GHG emissions in this expanded view.

**Figure 4. Multiple factors led to changes in absolute emissions in the expanded view**




5 Our estimates, scaled from national data, indicate that ozone depleting substances (i.e.., CFCs) may have accounted for over 1 million t CO2e in 1990, dropping substantially thereafter.

# DETAILED RESULTS AND METHODOLOGY BY SECTOR

The sections above showed Seattle's "core" and "expanded" greenhouse gas emissions. The expanded view differed from the core in that it included additional emissions sources associated with industry; marine, rail, and air travel; yard equipment; and wastewater treatment. The following sections show more detailed emissions results by sector, including information on the data sources and calculations for all sources included in both the core and expanded views. We append section titles for sectors or subsectors with "core" or "expanded" in parentheses to reflect the relevant approach, noting that all core sources are also included in expanded.

## Transportation

The transportation sector includes road, marine, rail, and air travel.

### *Road Transportation (Core and Expanded)*

Road transportation includes the emissions from fuel use by both passenger and freight vehicles (Table 4). The Puget Sound Regional Council (PSRC) modeled and provided an estimate of vehicle miles traveled (VMT) on streets and highways, on which emissions from commercial trucks, cars and light trucks, and van pools were based. Emissions from buses were calculated based on scheduled bus miles and fuel efficiency data provided by King County Metro.

As many vehicle trips involving Seattle are not completely contained in the city or involve vehicles passing though the city without stopping, emissions attribution to Seattle from road transportation is not straightforward. To estimate these emissions, this inventory employs an origin-destination pair methodology which counts all emissions from trips occurring entirely in the city boundaries and one-half of emissions from trips that either commence or end in the city. No emissions from trips that both begin and end outside Seattle are included, even if they pass through the city limit. The rationale for this method is that it focuses on the trips that local government can best influence through transportation planning, programs, and incentives, while excluding trips over which the city and its partners have little influence.

Emissions from the road transportation sector continue to increase in Seattle and were up over 190,000 $tCO_2e$ or 9% from 1990 in 2012. The increase in road transport emissions is driven primarily by growth in Seattle's population (up 23% since 1990) and economy. Vehicle emissions intensity has declined (11% for cars and light trucks, 7% for freight trucks), as has per-person personal vehicle travel (Figure 5, Table 4).

**Figure 5. Seattle's passenger vehicle travel per person over time**
(origin-destination-pair basis)

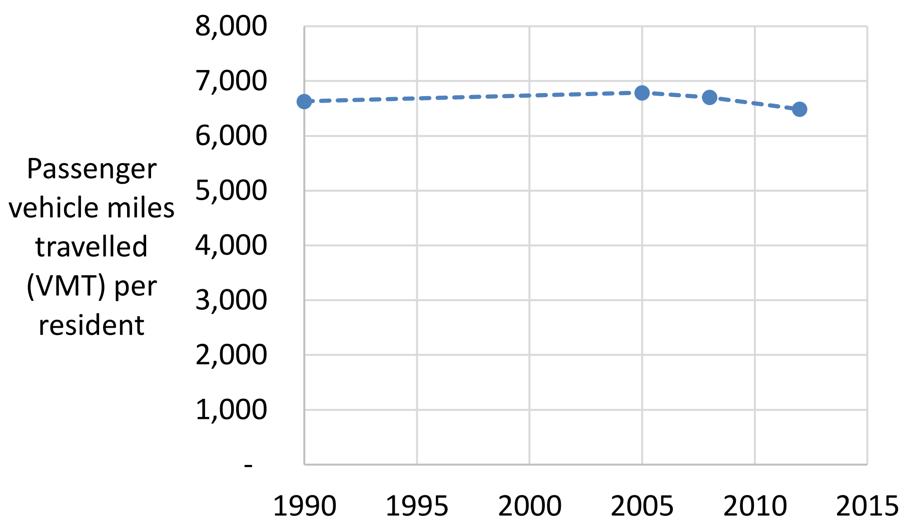



**Table 4. Road Transportation Emissions (Metric Tons $CO_2e$)**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| *Car & Light Duty Truck* | 1,512,000 | 1,572,000 | 1,510,000 | 1,603,000 |
| *Truck* | 635,000 | 681,000 | 677,000 | 720,000 |
| *Bus* | 47,000 | 54,000 | 66,000 | 64,000 |
| *VanPool* | 2,000 | 2,000 | 2,000 | 2,000 |
| **Totals** | **2,196,000** | **2,309,000** | **2,255,000** | **2,389,000** |

**Source Notes**

This inventory employs a method that counts emissions from all trips that occur entirely within Seattle, half of trips that either begin or end in the city, and no trips that both begin and end outside the city (even if they pass through the city, e.g. on I-5), known as an origin-destination pair approach. This is an increasingly common way of counting GHG emissions in community-scale inventories, and was recommended in ICLEI's recent *U.S. Community Protocol*.

Road transportation emissions were predominately calculated from daily average vehicle miles traveled (VMT) modeling results provided by PSRC for cars and light trucks, vanpool, and trucks (medium and heavy duty). The table below categorizes total average weekday VMT from all vehicles traveling entirely in, starting in, or ending in Seattle in 2011 **(12-11-06)**. The shaded area depicts the VMT that are counted according to the origin-destination pair method (and totaling 12,998,661 miles): 100% of trips contained within Seattle, 50% of trips with an origin or destination in Seattle, and 0% of trips that both start and end outside Seattle.

| *Origin* \ *Destination* | Seattle | Outside Seattle |
|---|---|---|
| Seattle | 4,633,466 | 8,033,767 |
| Outside Seattle | 8,696,623 | |

To estimate VMT for 2012, PSRC's modeled VMT results for 2011 **(12-11-08)** were scaled by a ratio of 2012 to 2011 total VMT on state highways in urban King County from the Washington State Department of Transportation (**12-11-09**). WSDOT uses a consistent methodology from year to year for these roads, which carry about half of total VMT in King County and which were therefore judged to be a purer signal of changes in VMT from year to year than data provided by WSDOT to the federal Highway Performance Management System (HPMS), for which WSDOT data on state highways are supplemented with sampled data for local roads but for which uncertainty is higher and methods have changed over time.

To estimate VMT for 2005, PSRC's VMT modeling results by vehicle type for 2006 **(12-11-07)** were scaled to 2005, also using WSDOT data on all VMT on state highways in urban King County (**12-11-10**), as described above. To estimate VMT for 2008, PSRC's VMT modeling results for 2008 **(12-11-12)** were used.

**Source Notes (continued)**

All VMT estimates derived from PSRC models (i.e. those for 2005, 2008, and 2012) are for average weekdays,. They are scaled downward slightly to reflect the fact that average traffic on weekends – and therefore on an average day – is somewhat lower than on an average weekday. Scaling factors for 2005, 2008, and 2012 were developed by analyzing weekday and daily vehicle counts over time at two traffic stations in Seattle (one on I-5, one on I-90) from WSDOT's *Annual Traffic Report* (**12-11-09**). Factors must also be developed to scale up the results to account for the fact that the models do not include VMT for trips that both begin and end within one of the many traffic analysis zones in PSRC's model. This factor was assumed to be 0.3% for all years based on communication with PSRC staff (**12-11-11**).

Estimating VMT for 1990 using the origin-destination pair approach is more complicated, and more uncertain, because modeling results using this method are not available from either PSRC or SDOT. VMT on a purely geographic basis (all VMT that occur within the city, regardless of origin or destination) for 1990 **(05-124)** were split into vehicle types using data from 2000 **(05-123)**, the earliest available, and then adjusted upward by the estimated (vehicle-specific) ratios of origin-destination pair to purely geographic VMT in 2005, also the earliest (ratio) available.

Finally, in order to calculate emissions, annual VMT were multiplied by emissions factors derived from national average, vehicle-type-specific fuel efficiencies (miles per gallon) published in *National Transportation Statistics* **(12-11-01 through 12-11-04)** and fuel-specific (gasoline or diesel) carbon contents from the US EPA's national GHG inventory **(12-801)**.

Bus miles travelled and total fuel use in 2012 were calculated using bus fleet average fuel economy, excluding miles served by electric trolleys, and miles travelled **(12-11-13)** for 2012 provided by King Country Metro. The bus-miles travelled were scaled to Seattle by taking the ratio of total fleet miles to Seattle miles from 2008 and assigning the same ratio to the total fleet miles in 2012 **(12-11-15)**.

Calculation steps and data sources for Road Transportation are listed in **12-00-0_MasterSpreadsheet '*Trans-Road Traffic'*** tab.

Uncertainty exists both in the estimates of vehicle travel (VMT) and vehicle fuel efficiency, the two primary drivers of road transport GHG emissions. Sources of uncertainty for VMT include that in PSRC's underlying model and in the scaling method used to scale PSRC's 2011 model results to 2012 based on data from WSDOT. Vehicle fuel efficiencies are based on national fuel economy statistics, for which methods have changed over time, and which may not directly correspond to the efficiency of vehicles in Seattle.

### *Marine & Rail Transportation (Expanded only)*

Marine and rail transportation are not included in Seattle's core emissions, and comprised a minor share (4%) of the expanded GHG inventory for 2012. Marine transportation includes pleasure craft, Washington State Ferries, cruise ships, cargo vessels, and other commercial boat traffic, such as tug boats. Emissions that occur near shore (maneuvering) and on-shore (hoteling) are included based on estimates conducted by the Puget Sound Maritime Air Forum. Freight rail transportation includes emissions, based on the Puget Sound Maritime Air Forum Air Emissions inventory, from locomotive use at the Port of Seattle (on-terminal), the movement of Port of Seattle-related cargo in the county (off-terminal), and the movement of other freight. Emissions associated with passenger rail (Amtrak, Sounder commuter, and Link Light Rail) are also included. Marine and rail transportation emissions declined just over 11% from 1990 and 16% from 2008, with reductions in rail freight and large ship hoteling emissions contributing the largest share of the reductions. Emissions from marine and rail transportation are presented in Table 5.

**Table 5. Marine and Rail Transportation Emissions (Metric Tons $CO_2e$)**

| | Emissions, Metric Tons $CO_2e$ | | | |
|---|---|---|---|---|
| | **1990** | **2005** | **2008** | **2012** |
| *Hoteling* | 53,000 | 51,000 | 74,000 | 46,000 |
| *Washington State Ferries* | 41,000 | 42,000 | 35,000 | 42,000 |
| *Pleasure Craft* | 32,000 | 30,000 | 31,000 | 31,000 |
| *Other Ship & Boat Traffic* | 65,000 | 62,000 | 64,000 | 64,000 |
| *Rail - Freight* | 85,000 | 81,000 | 79,000 | 53,000 |
| *Rail - Passenger* | 1,000 | 9,000 | 10,000 | 12,000 |
| **Totals** | **276,000** | **274,000** | **293,000** | **247,000** |

**Source Notes**

**Other Ship and Boat Traffic:** Emissions for 2012 were based on the 2011 Puget Sound Maritime Air Emissions Inventory **(12-001)**, including Ocean Going Vessel (OGV) Maneuvering, and Harbor Vessels (less Ferry emissions) categories. The 2011 emissions for OGV maneuvering were scaled by 2012 port tonnage handled (in TEUs) relative to 2011 as well as the increased number of cruise vessels in 2012 **(12-12-01)**. Harbor vessel emissions reported for King County **(12-001, Table 4.11)** were scaled to 2012 city population. The reported harbor vessel emissions include ferry emissions **(12-001)**, which are determined and reported separately, so are subtracted out from the harbor vessel emissions reported by the Puget Sound Maritime inventory. Port tonnage handled in 2005 and 2008 was updated to reflect the most current values available **(12-12-01)**, but all other inputs and calculation steps remained the same as previously reported.

**Hoteling**: Emissions for 2012 were based on the 2011 Puget Sound Maritime Air Emissions Inventory **(12-001, Table 2.15)**. The 2011 values were scaled to 2012 by Port tonnage handled (in TEUs) and the number of cruise calls not using shore power **(12-12-01)**. Port tonnage and total port calls for 2005 and 2008 were updated based on source **12-12-01**, but all other inputs and calculations steps remained the same as previously reported for other inventory years.

**WA State Ferries:** For 2012, diesel and biodiesel fuel use for all Washington State Ferries (WSF), as reported by the Washington State Department of Enterprise Services **(12-12-03),** was multiplied by the fraction of fuel expenditures for WSF servicing each of the Seattle routes, as determined based on the WSF 2012 fiscal year route statements **(12-12-02).** One-half of fuel use for these routes was attributed to Seattle, consistent with the origin-destination pair approach described above for other passenger transport. An emission factor (kg$CO_2$/gallon) from the *ICLEI Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions Version 1.0* **(12-12-05)** was used to calculate emissions associated with biodiesel fuel use. This method is consistent with, though not identical, to the methods for prior years, which were not changed.

**Pleasure Craft:** Marine pleasure craft emissions for 2012 and 2005 are based on NONROAD modeling results for King County for the years 2005 and 2011, obtained from the Washington State Department of Ecology **(12-40-04, 12-40-01)**. The sum of diesel and gasoline use by marine pleasure craft was scaled by the Seattle fraction of King County population. Modelled fuel use in 2011 was also scaled to 2012 population to estimate 2012 fuel use. The 2008 fuel use is scaled by population growth to 2005 emissions. Fuel use in 1990 is only available based on PSCAA NONROAD modelling results. The PSCAA NONROAD and Dept. of Ecology NONROAD modelling results for pleasure craft differ due to methodologies for attributing county scale emissions from statewide emission. Therefore, the 1990 PSCAA NONROAD fuel use was scaled by the ratio of Dept. of Ecology modelled to PSCAA modelled fuel use in 2005 to estimate total fuel use in 1990.

**Rail - Freight:** Freight rail emissions reported are the sum of Port of Seattle on-terminal (line-haul and switching locomotives, reported for 2011 in Puget Sound Maritime Air Emissions Inventory **12-001**) and off-terminal (King County line-haul locomotive) emissions. King County off-terminal line-haul locomotive emissions were not provided for 2011, as they were for 2005 **(05-151**) and therefore were determined by scaling the ratio of total airshed emissions for 2011 relative to 2005. Seattle is assigned 90% of the King count off-terminal emissions, consistent with previous inventory years **(05-156)**. Emissions for 2012 were scaled relative to those reported for 2011 by the ratio of tonnage handled, in twenty-foot equivalent units (TEUs) **(12-12-01)**. Rail emissions reported for 2005 (and by effect the scaled 1990 and 2008 emissions) are higher than previously determined, due to the correction of a calculation error in accounting for off-terminal emissions from non-Port of Seattle related freight.

**Source Notes (continued)**

**Uncertainty.** Uncertainty in emissions data for Washington State Ferries is relatively low, as they are based on fuel usage statistics. By contrast, uncertainties for other sources are relatively high as they are based on model output that in some cases (e.g., for pleasure craft) scale national data to Seattle.

### *Air Transportation (Expanded only)*

Emissions from air transportation are included in the expanded view of the GHG inventory and include a share of emissions associated with passenger travel at Seattle-Tacoma International Airport, as well as all fuel distributed at King County International Airport (KCIA), mostly for freight, in 2012.[6]

Emissions attributed to Seattle from Sea-Tac airport are the estimated share of all the emissions from trips in and out of Sea-Tac associated with residential and business activities in Seattle. Seattle's share of Sea-Tac Airport airline emissions of 17% is determined by the relative share of Seattle's population (representing personal travel) and employment (representing business travel) in the region, based on Census Bureau and Washington Employment Security Department sources. Emissions from air transport are shown in Table 6.

**Table 6. Air Transportation Emissions (Metric Tons $CO_2e$)**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| *Sea-Tac International Airport* | 756,000 | 688,000 | 718,000 | 681,000 |
| *King County International Airport* | 184,000 | 216,000 | 258,000 | 224,000 |
| **Totals** | **940,000** | **904,000** | **976,000** | **905,000** |

[6] Fuel distributed at King County is largely dependent on purchases by UPS. KCIA staff report that the decline in fuel use (and hence emissions) between 2008 and 2012 is largely a result of UPS refueling more at other stops in the planes' itineraries instead of at KCIA. In addition, small aircraft operations remain below normal by 15% or more in the wake of the economic downturn.

**Source Notes**

**Sea-Tac International Airport:** The Port of Seattle provided data for total jet fuel distributed to aircraft at Sea-Tac Airport **(12-90-06)**. The fraction of emissions attributable to Seattle was estimated with a composite of population and employment in the city compared to the greater Puget Sound region, from which Sea-Tac is assumed to draw its passengers **(12-14-01)**. This methodology replaces the previous approach, which assigned the Seattle resident fraction of Sea-Tac passengers based solely on a 2001 Passenger Survey **(08-14-10)**. Under the current approach, Seattle residents make up a lower percentage of Sea-Tac passengers than indicated by the Survey. Only domestic flights, both passenger and cargo, were considered in these calculations (no international flights were included).

**King County International Airport:** King County International Airport (KCIA) provided data for jet fuel and aviation gas distributions in 2012 **(12-90-07)**. All resulting emissions are attributed to Seattle, to account for roughly half of emissions associated with air travel to and from KCIA (since presumably fuel associated with inbound flights would be approximately equal to fuel associated with outbound flights, assuming similar origins and destinations). This approach is consistent with the origin-destination pair approach taken for road travel to and from Seattle. Emissions associated with Sea-Tac are treated differently since it is not located within Seattle's boundaries. Calculations for prior years were updated to this simpler method **(12-14-03, 12-14-04)**. Previously, KCIA emissions were calculated as "landing-takeoff", or LTO emissions, which counts only the emissions associated with takeoffs and landings. The KCIA emissions do not include fuel flow for Boeing operated aircraft, which are fueled at a separate facility from and for which fuel use data is not available for all inventory years.

Calculation steps and data sources are listed in **12-00-0_MasterSpreadsheet '*Trans- Air Traffic*'.**

**Uncertainty.** Uncertainty in emissions from air travel via Sea-Tac attributed to Seattle is relatively high, because even as fuel usage at the airport is well known, the method for attributing emissions to Seattle assumes that passenger travel for household and business travel is identical (per person and employee, respectively) across the region, despite demographic differences (e.g., in income, or in type of employment). By contrast, uncertainty in emissions at King County international airport is relatively low, as it is based directly on fuel usage data.

## Buildings

Seattle's core emissions include GHGs associated with the energy consumed by Seattle's residential and commercial buildings for lighting, appliances, heat, and hot water. The expanded view also includes emissions associated with landscaping, yard, and other equipment used at buildings.

Including all sources, emissions in this sector declined 196,000 $tCO_2e$, or 12%, between 1990 and 2012, and 121,000, or 8%, since 2008. Electricity and oil emissions declined while natural gas use increased. Lower residential building emissions account for most (over 90%) of the decline between 1990 and 2012.

### *Residential Building Energy (Core and Expanded)*

The vast majority of residential building emissions are associated with energy used for home heating, appliances, and hot water. Emissions from residential building energy are shown in Table 7. Emissions from residential building energy were lower in both major categories (direct fuel use and electricity) compared to 1990 and 2008. This can largely be attributed to fuel switching from heating oil to natural gas, Seattle City Light's transition away from fossil fuel sources in the electricity supply, and improvements in energy efficiency.

**Table 7. Residential Building Energy Emissions (Metric Tons $CO_2e$)**

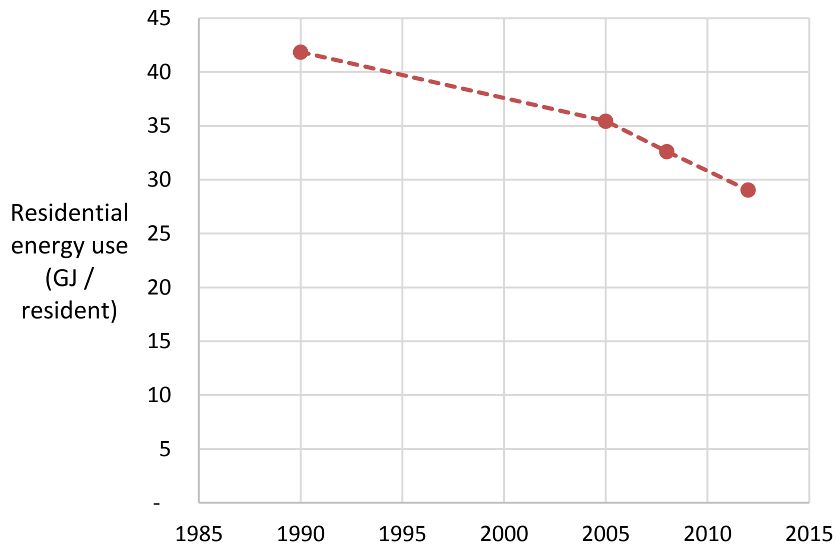
| | Emissions, Metric Tons $CO_2e$ | | | |
|---|---|---|---|---|
| | **1990** | **2005** | **2008** | **2012** |
| ***Electricity*** | 133,000 | 68,000 | 44,000 | 28,000 |
| ***Direct Fuel Use*** | | | | |
| *Natural gas* | 259,000 | 371,000 | 432,000 | 420,000 |
| *Oil* | 329,000 | 131,000 | 131,000 | 89,000 |
| ***Totals*** | **721,000** | **570,000** | **608,000** | **538,000** |

To further explore trends in residential building energy use, Figure 6 displays household energy use per person over time, which is down 31% since 1990. Factors that help explain the decline in Seattle's residential energy use per person include smaller average household floor area[7], increased energy efficiency of lighting, appliances, and heating, and the switch from oil heat to natural gas.[8]

[7] Though no data on actual floor area were identified, based on data from the Census Bureau's American Community Survey, in recent years (since 2005), about two-thirds of the net additions to households in Seattle have been (generally smaller) households in buildings with more than two units, compared to less than half (45%) of the existing housing stock.

[8] According to the U.S. Department of Energy, older oil furnaces have an efficiency of 56% to 70%, whereas newer natural gas furnaces have efficiencies of 90% or more. An estimated 30,000 households have converted from oil heat since 1990.

**Figure 6. Residential energy use per person, Seattle.**
(excluding yard equipment)




**Source Notes**
When needed, fuel-specific emissions factors ($gCO_2/L$) from the US EPA's national GHG inventory (**12-801**) were used.

**Electricity:** Seattle City Light (SCL) provided residential building electricity consumption within Seattle for 2012 **(12-90-04)** and the utility emission factor ($tCO_2/MWh$) **(12-90-21)**. The SCL emission rate was multiplied by residential electricity consumption to obtain total emissions.

**Direct Fuel Use (Natural Gas):** Puget Sound Energy (PSE) provided 2012 natural gas use by Seattle residences **(12-20-02)**.

**Direct Fuel Use: (Heating Oil):** Seattle residential oil use was estimated from 2011 Washington State Distillate Fuel Oil and Kerosene sales by end-use, which is reported by the U.S. Energy Information Administration **(12-40-03)** and scaled to Seattle by the ratio of Seattle homes with oil heat to Washington State homes with oil heat as reported for 2012 by the U.S. Census Bureau American Fact Finder database **(12-20-01).**

Calculation steps and data sources for electricity, natural gas and petroleum (heating) are listed in **12-00-0_MasterSpreadsheet '*Electricity*', and '*Res- Heat & Hot Water*'** tabs, respectively.

**Uncertainty.** Uncertainty in electricity and natural gas is quite low, since it is based directly on utility data. Uncertainty in oil use, on the other hand, is relatively high, since this is scaled from statewide data and assumes that per household fuel use in Seattle is the same as for Washington State as a whole .

### *Commercial Building Energy (Core and Expanded)*

Commercial building emissions are from the energy consumed by businesses, office buildings, and institutional facilities (such as government buildings and schools). Like residential building emissions, the majority of these emissions are associated with lighting, space heating, and hot water. Many downtown Seattle buildings are heated by steam generated by Seattle Steam Company, and the emissions associated with steam heat are reported on a separate line. GHG emissions from commercial buildings are shown in Table 8.

**Table 8. Commercial building energy emissions (metric tons $CO_2e$)**

| | Emissions, Metric Tons $CO_2e$ | | | |
|---|---|---|---|---|
| | **1990** | **2005** | **2008** | **2012** |
| ***Electricity*** | 169,000 | 102,000 | 82,000 | 53,000 |
| ***Direct Fuel Use*** | | | | |
| *Natural Gas* | 281,000 | 351,000 | 401,000 | 402,000 |
| *Oil* | 150,000 | 84,000 | 108,000 | 93,000 |
| ***Steam Plants*** | | | | |
| *Natural Gas* | 137,000 | 160,000 | 176,000 | 156,000 |
| *Oil* | 7,000 | - | 1,000 | - |
| ***Totals*** | **744,000** | **698,000** | **767,000** | **705,000** |

**Source Notes**

**Electricity:** Seattle City Light (SCL) provided commercial building electricity consumption within Seattle for 2012 **(12-90-04)** and the utility emission factor ($tCO_2$/MWh) **(12-90-21)**. The SCL emission rate was multiplied by commercial electricity consumption to obtain $CO_2$ emissions.

**Direct Fuel Use (Natural Gas):** Puget Sound Energy (PSE) provided 2012 natural gas use by Seattle commercial customers **(12-20-02).** Natural gas use at steam plants and for commercial equipment use as CNG are assumed to be included in PSE's reported commercial sector natural gas totals, but are subtracted from the total reported by PSE and given separately for the purposes of this inventory.

**Direct Fuel Use (Petroleum):** Seattle commercial building oil use was estimated using 2011 Washington State Distillate Fuel Oil and Kerosene sales by end-use, which is reported by the U.S. Energy Information Administration **(12-40-03),** prorated by the ratio of Seattle to Washington State commercial employment **(12-70-11),** then scaled by Seattle 2012 commercial employment relative to 2011.

**Steam:** PSCAA provided natural gas and back up oil use from the Seattle Steam and the University of Washington Steam Plant **(12-40-05)**. Seattle Steam also used 8,541 tons of wood waste in 2012 (12-40-05), which is counted here as zero emissions following the primary practice used in the EPA's national inventory. To first order, this wood resulted in direct emissions of approximately 16,000 $tCO_2$, which would add about 10% to the estimated emissions from steam production if counted. Future efforts may wish to develop alternate approaches, such as a life-cycle-based emission factors, to counting GHG emissions associated with biomass combustion.

Calculation steps and data sources for electricity, natural gas (commercial equipment) and petroleum (commercial equipment), natural gas (heat and other), petroleum (heat and other), and steam are listed in **12-00-0_MasterSpreadsheet** **'*Electricity*'**, **'*Commercial- equip*'**, and **'*Commercial- Heat & Hot Water*'**, respectively.

**Uncertainty.** Uncertainties for commercial building emissions estimates are similar to residential buildings: low uncertainty for natural gas and electricity; high uncertainty for oil use. Emissions associated with steam plants are relatively certain, since they are based directly on fuel use data.

### *Residential and Commercial Building Equipment (Expanded only)*

The expanded view of Seattle's commercial building emissions also include emissions from small equipment associated with commercial operations, including landscaping equipment.

### Table 9. Residential and commercial building equipment emissions (metric tons $CO_2e$)

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| ***Residential Yard Equipment*** | | | | |
| *Diesel* | <100 | <100 | <100 | <100 |
| *Gasoline* | 20,000 | 17,000 | 17,000 | 19,000 |
| *LPG* | <10 | <11 | <12 | <13 |
| ***Commercial Equipment*** | | | | |
| *Diesel* | 29,000 | 37,000 | 39,000 | 46,000 |
| *Gasoline* | 91,000 | 90,000 | 95,000 | 96,000 |
| *LPG* | 3,000 | 4,000 | 4,000 | 5,000 |
| *CNG* | 12,000 | 14,000 | 14,000 | 16,000 |

**Source Notes**

**Residential Yard Equipment (Petroleum):** King County yard equipment fuel use in 2011 was estimated by the Washington Department of Ecology using EPA's NONROAD model, and relevant model output was provided **(12-40-01)**. Fuel-use by petroleum type was tabulated **(12-40-02),** prorated for Seattle by the ratio of Seattle to King County population, then scaled by Seattle 2012 population relative to 2011

**Commercial Equipment (Natural Gas and Petroleum):** King County compressed natural gas (CNG) and petroleum fuel use for equipment in 2011 was estimated by the Washington Department of Ecology using EPA's NONROAD model and relevant model output was provided **(12-40-01)**. Fuel-use was tabulated by fuel type and sector **(12-40-02)**, then scaled to Seattle by the ratio of Seattle to King County commercial employment **(12-70-11),** and scaled by Seattle 2012 commercial employment relative to 2011.

**Uncertainty.** Uncertainty is high for residential and commercial equipment, since it is based on a national model.

### *Industry (Expanded only)*

The industrial sector includes emissions from industrial operations, the manufacturing of cement, steel, and glass, and fugitive gases associated with equipment. Emissions include those associated with electricity consumption (from fossil fuel generated electricity purchased by SCL). Industrial emissions are not included in Seattle's core emissions, but are described here since they are part of the expanded view.

### *Cement*

Emissions associated with cement production are presented in Table 10. These include emissions from fuel combustion (natural gas, oil, coal, and tire-derived fuels) and the release of carbon dioxide from the calcination process involved in clinker production. Emissions from cement production in Seattle have come from two large plants, which have not constantly operated during all inventory periods. Both plants were active in 2005 and 2008, but only one in 1990 and 2012. We report the actual emissions associated with cement production within the city boundary for each inventory year. These emissions should be interpreted with care, as they are influenced greatly by market forces (e.g. competition from other cement producers, economic conditions determining annual demand levels) beyond the control of policy decisions made at the city-level.

**Table 10. Greenhouse gas emissions associated with cement production (Metric Tons $CO_2e$)[9]**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| *Fuel combustion* | 211,000 | 377,000 | 353,000 | - |
| *Clinker calcination* | 206,000 | 484,000 | 393,000 | - |
| **Total** | **417,000** | **861,000** | **746,000** | **307,000** |

**Source Notes**

**Cement:** Emissions associated with cement production in 2012 are taken from the EPA 2012 Ash Grove Greenhouse Gas Emissions from Large Facilities report **(12-40-06)**. This report does not separate emissions associated with fuel combustion from emissions associated with clinker calcination. The 1990 emissions previously included a baseline cement adjustment to account for temporary closure of one of the two plants. As only one plant also operated in 2012 that adjustment is excluded here. Because production levels continued to fluctuate throughout all inventory periods, actual emissions are reported for all inventory years. Calculation steps and data sources for cement, steel and glass, and ODS substitutes and fugitive gases are listed in **12-00-0_MasterSpreadsheet 'Ind-Cement'**.

**Uncertainty.** Uncertainty in cement emissions is relatively low, as these estimates are based on actual data on fuel usage and clinker production (1990 through 2008) and on data reported directly to the US EPA by the facility (2012).

[9] Cement production emissions from relevant facilities are taken from the EPA's 2012 Greenhouse Gas Emissions from Large Facilities. These do not report separate fuel combustion and clinker calcination emissions.

### *Other Industry – Energy Use*

Industrial operations include emissions from energy consumed by industrial facilities located in Seattle. Industrial operations are dominated by emissions from energy used to fuel manufacturing or other industrial equipment, rather than space heating and hot water as in the residential and commercial sectors. Industrial operations also include fuel use and GHG emissions from construction equipment, material handling, and other off-road machinery. Emissions from industrial energy use (other than for cement production) are shown in Table 11.

**Table 11. Industrial energy use emissions, other than for cement (metric tons $CO_2e$)**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| ***Electricity*** | 62,000 | 26,000 | 17,000 | 10,000 |
| ***Direct Fuel Use*** | | | | |
| *Natural gas* | 266,000 | 246,000 | 232,000 | 259,000 |
| *Oil* | 49,000 | 24,000 | 36,000 | 16,000 |
| *Coal* | 211,000 | 339,000 | 335,000 | - |
| *Tire-derived Fuel* | - | 26,000 | 17,000 | - |
| ***Industrial Equipment*** | | | | |
| *Diesel* | 114,000 | 131,000 | 172,000 | 158,000 |
| *Gasoline* | 6,000 | 4,000 | 6,000 | 3,000 |
| *LPG* | 20,000 | 25,000 | 33,000 | 27,000 |
| *CNG* | 11,000 | 13,000 | 17,000 | 13,000 |
| ***Totals*** | **739,000** | **835,000** | **866,000** | **488,000** |

**Source Notes**

**Electricity:** Seattle City Light (SCL) provided Industrial electricity consumption within Seattle for 2012 **(12-90-04)** and the utility emission factor ($tCO_2$/MWh) **(12-90-21)**. The SCL emission rate was multiplied by Industrial electricity consumption to obtain $CO_2$ emissions.

**Direct Fuel Use (Natural Gas):** Puget Sound Energy (PSE) provided 2012 natural gas use by Seattle Industrial customers **(12-20-02)**, from which natural gas used for industrial equipment (see below), which was assumed to be included in PSE's estimates for the industrial sector, was subtracted out (as in commercial sector).

**Direct Fuel Use (Petroleum):** Seattle commercial building oil use was estimated using 2011 Washington State Distillate Fuel Oil and Kerosene sales by end-use, which is reported by the U.S. Energy Information Administration **(12-40-03)**. Fuel sales were scaled by the ratio of Seattle to Washington State Industrial employment **(12-70-11)** then by Seattle 2012 Industrial employment relative to 2011.

**Industrial Equipment (Natural Gas and Petroleum):** King County Industrial compressed natural gas (CNG) and petroleum fuel use for equipment in 2011 was estimated by the Washington Department of Ecology using EPA's NONROAD model and relevant model output was provided **(12-40-01)**. Fuel-use by fuel type and sector was tabulated **(12-40-02)**, then prorated for Seattle only by the ratio of Seattle to King County industrial employment **(12-70-11)** and scaled by Seattle 2012 Industrial employment relative to 2011.

Calculation steps and data sources for electricity, natural gas (industrial equipment) and petroleum (industrial equipment), and natural gas (heat and other), petroleum (heat and other), coal, and tire are listed in **12-00-0_MasterSpreadsheet 'Electricity', 'Ind- Small Equipment**, and **'Ind- Operations',** respectively.

**Uncertainty.** Uncertainties for industrial energy use are similar to those for building energy use, i.e. higher for direct oil use (scaled from statewide data according to industrial employment) and industrial equipment fuel use (model-based), and relatively certain natural gas and electricity emissions based on utility sales data.

## *Other Industry – Process Emissions & Fugitive Gases*

Industrial process emissions include GHGs that are emitted directly from production of steel and glass, as well as the emissions from fugitive gases from electric switchgear equipment. Additional sources of emissions associated with industry are ozone-depleting substance (ODS) substitutes (mainly hydrofluorocarbons) used largely in refrigeration and air-conditioning equipment and sulfur hexafluoride released from electric switchgear insulation. [10] Industrial process and fugitive gas emissions totals are presented in Table 12. The increase of over 30,000 $tCO_2e$ since 2008 and 240,000 $tCO_2e$ since 1990 is almost exclusively attributable to increased use of ODS substitutes, with some additional from steel and gas production.

[10] Emissions from substitutes for ozone-depleting substances (ODS) are assigned here to industry but include emissions that could be considered the responsibility of other sectors, such as releases of hydrofluorocarbons found in commercial and residential air conditioning and refrigeration equipment.

### Table 12. Industrial process and fugitive gas emissions (metric tons $CO_2e$)

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| **Process Emissions** | | | | |
| *Steel and glass* | 20,000 | 37,000 | 40,000 | 39,000 |
| **Fugitive Gases** | | | | |
| *ODS Substitutes* | 1,000 | 192,000 | 202,000 | 235,000 |
| *Switchgear insulation (SF6)* | 10,000 | 5,000 | 2,000 | 1,000 |
| **Totals** | **31,000** | **234,000** | **244,000** | **275,000** |

**Source Notes**

**Steel:** Steel emissions are from Seattle's predominant manufacturer, Nucor (an electric arc furnace that produces crude steel). PSCAA provided production data from Nucor steel production **(12-40-102)**. To calculate emissions, the production data was multiplied by the nominal IPCC emission factor associated with electric arc furnaces, 1.25 $kgCO_2$/Mg steel. Nucor uses entirely recycled stock so there are no emissions associated with carbon lost from pig iron as there would be in a basic oxygen furnace **(05-127).**

**Glass:** Glass operations emissions are from manufacturing at Seattle's Saint-Gobain Containers. PSCAA provided production data from this facility **(12-40-111)**. To calculate emissions, tons of glass pulled were multiplied by the default emission factor for glass manufacturing **(KC08-40-2)** and adjusted by the ratio of recycled cullet used by Saint-Gobain **(KC08-40-3).** Emissions from glass operations were calculated based on tons of glass pulled as reported in the 2008 King County Inventory and previous Seattle inventory source documents **(05-098)**.

**ODS Substitutes:** Emissions associated with substitutes for ozone-depleting substances (ODS) for all inventory years were estimated using the EPA's State Inventory Tool *Industrial Processes Module* **(12-40-04)**. The ODS emissions from the IP module were down-scaled to Seattle by the relative population of Seattle to Washington State **(12-70-11)** in each of the reported years. As the IP module only reports through 2010, emissions for 2012 were adjusted based on the ratio of 2012 to 2010 Seattle Industrial Employment **(12-70-11)**.

**Fugitive Gases:** Seattle City Light (SCL) provided fugitive $SF_6$ emissions for 2012 (**12-90-04)**, which were converted to $CO_2$-equivalent emission based on the 100-year global warming potential of $SF_6$ (22,800) from the IPCC Fourth Assessment Report.

Calculation steps and data sources for cement, steel and glass, and ODS substitutes and fugitive gases are listed in **12-00-0_MasterSpreadsheet 'Ind- Process'** and **'Ind- Fug. Gases'**, respectively.

**Uncertainty.** Uncertainty is relatively high for all categories of process and fugitive emissions, especially the largest category ODS substitutes, since based on scaling from national estimates.

## Waste

The waste sector includes emissions associated with the disposal of municipal solid waste (included as part of core emissions) and wastewater treatment (included in the expanded view). Solid waste emissions have declined 22% between 1990 and 2012 due to reduced waste generation and increased composting and recycling.

### *Waste Management (Core and Expanded)*

Because emissions from the disposal of solid waste primarily occur outside of the City boundaries and yet the management of solid waste, is within the City's sphere of influence, this inventory uses a "waste commitment" methodology to estimate emissions. The 'waste commitment' methodology estimates the total quantity of fugitive methane expected from the garbage disposed in the inventory year, throughout its entire decay process in the landfill. The decay process takes many years, so the fugitive methane occurs only partly during the inventory year, and partly in future years; however, all methane "commitment" is attributed to the year in which the waste was disposed.

Other emissions are also associated with municipal solid waste (MSW) generated in Seattle: namely, fossil fuel combustion associated with transporting waste to landfill, processing waste at the landfill, maintaining the landfill using heavy equipment, and other general activities required to maintain the landfill. These other emissions are also included in Table 13. The decrease in waste commitment emissions since 2008 is mainly attributable to reduced disposal of food scraps, which generate methane and store relatively little of their carbon under landfill conditions, and of other, non-food organics disposal.

Previous inventories counted waste sector emissions by estimating the emissions from waste in place in closed in-city landfills. These emissions are still tabulated (see *Other Perspectives on Seattle's Emissions* section).

### *Wastewater Treatment (Expanded only)*

A wastewater treatment plant, West Point, is operated by King County within the Seattle city limits. Wastewater treatment emits methane and nitrous oxide, both greenhouse gases.[11]

**Table 13: Waste Sector Emissions (Metric Tons $CO_2e$)**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| *Waste Management* | 122,000 | 124,000 | 115,000 | 95,000 |
| *Wastewater Treatment* | 2,000 | 2,000 | 2,000 | 2,000 |
| **Totals** | **123,000** | **126,000** | **117,000** | **97,000** |

[11] Due to rounding, changes in emissions associated with wastewater treatment are not displayed in this table.

**Source Notes**

**Waste management**: Emissions from the management of municipal solid waste (collection and transfer plus landfill emissions commitment) for all inventory years were provided by Jenny Bagby, Seattle Public Utilities **(12-50-02)**.

**Wastewater Treatment:** Wastewater treatment emissions for 2011 were provided by the King County Wastewater Treatment Division **(12-50-01)**. These include both stationary $CH_4$ emissions and process $N_2O$ emissions. Stationary $CH_4$ emissions for 2012 were scaled relative to 2011 based on population growth while $N_2O$ emissions are based on a population service area of 1.5 million and were scaled based on Seattle population in 2012.

Calculation steps and data sources for landfills and wastewater treatment are listed in **12-00-0_MasterSpreadsheet 'Waste- Landfills'** and **'Waste- Wastewater'**, respectively.

**Uncertainty.** Uncertainty in waste management emissions include estimates of methane release based on waste composition and methane release collection efficiencies over time (including for the future, which would affect methane emissions from waste generated in 2012). There is some uncertainty in both of these values, although the impact on total Seattle emissions is likely to be relatively small due to the small overall contribution of this source. Wastewater treatment uncertainty includes methane capture rate, which is likely uncertain, although applied to a very small level of emissions.

## Greenhouse Gas Offsets

The majority of Seattle City Light's electricity is generated from hydro and wind power, but there are some emissions associated with the power City Light purchases on the market. Since 2005, City Light has invested in carbon reduction projects to offset the emissions associated with its electricity production.

Currently, City Light purchases most of its offsets from agricultural and landfill methane capture projects using the Climate Action Reserve and other third party organizations that have established protocols for qualifying and verifying offsets.

City Light uses several criteria to evaluate offsets, and seeks projects that are local, verifiable, and reasonably priced. City Light pursues projects that reduce emissions beyond business as usual or regulatory requirements, can be replicated or adopted broadly, and have co-benefits to the environment and the economy. We include offsets associated with electricity use in the core and expanded views of the GHG inventory.

**Table 14. Greenhouse gas offsets counted in this inventory (Metric Tons $CO_2e$)[12]**

| | | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| | *Residential* | 74,000 | 44,000 | 28,000 |
| | *Commercial* | 113,000 | 82,000 | 53,000 |
| | *Industrial* | 29,000 | 17,000 | 10,000 |
| **Total** | | **216,000** | **143,000** | **91,000** |

[12] Greenhouse gas offsets counted here are equivalent to all the emissions associated with electricity generation consumed in Seattle. The total quantity of offsets purchased by Seattle City Light may be greater than this amount, since City Light's service territory is slightly bigger than Seattle city limits.

# OTHER PERSPECTIVES ON SEATTLE'S EMISSIONS

This report includes two perspectives on Seattle's emissions – a core and an expanded view. Other perspectives are also possible, however. Most communities in the U.S., Seattle included, consume more goods and materials than they produce. How to account for the GHG emissions associated with these goods and materials has been the subject of considerable debate, including among those who design protocols for community-scale emissions. These other perspectives do not always fit neatly into GHG inventories. Even the approaches used here are hybrids of "production" approaches (which are more inclusive of emissions associated with producing goods and materials in a community) and "consumption" approaches (which are more inclusive of emissions associated with consuming goods and materials in a community, regardless of where the emissions are released).

## Producing Goods and Materials

Seattle produces several energy-intensive materials – namely cement, steel, and glass. Because these facilities are serving regional – even international – markets, the quantities of materials produced vary based on trends that exist far beyond Seattle's borders. As a result, GHG emissions associated with producing these materials can also vary widely, causing Seattle's GHG emissions to fluctuate (sometimes greatly) based on factors beyond its influence. Tracking the GHG emissions *intensity* of these materials would avoid this problem, and help focus attention on the ability that local governments may have to influence GHG emissions at these facilities, such as by helping to provide lower-GHG fuels or providing opportunities to use waste heat (e.g., from cement kilns).

The table below shows the estimated GHG intensity of cement production over time, based on reported in-city cement production and fuel use data for the Ash Grove and Lafarge cement kilns. The emissions intensity of cement production is affected primarily by the relative balance of production at Ash Grove and Lafarge. The Lafarge kiln (no longer in operation) was a more energy-intensive, vertical shaft kiln.[13]

**Table 15. Emissions intensity ($tCO_2$/t clinker produced) of cement production in Seattle**

| | Emissions intensity, MtCO2 / t clinker | | | |
|---|---|---|---|---|
| | 1990 | 2005 | 2008 | 2012 |
| Cement production | 1.12 | 0.96 | 1.02 | 0.94 |

Based on data limitations, we do not report the emissions intensity of steel or glass production here.

[13] In 1990, only the Lafarge cement kiln was operational. In 2012, only the Ash Grove kiln was operational. Data were not available for the $CO_2$-intensity of clinker production at Ash Grove in 2012, and so the 2008 figure for Ash Grove is reported here.

## Consuming Goods and Materials

Another way to look at emissions associated with goods and materials would be to count all the emissions associated with the goods and materials (and services) consumed in Seattle, regardless of where they were made. For example, the production of a t-shirt or appliance involves energy inputs at various places all around the world. Estimating emissions associated with goods and services is a complicated endeavor that involves modeling of the economy and a number of assumptions. In 2011, Seattle collaborated with King County to undertake an extensive study that estimated all "consumption based" emissions at 25 $tCO_2e$ per person for the year 2008: more than 5 $tCO_2e$ per person were associated with goods and about 4 t $CO_2e$ per person were associated with food. For more information on emissions associated with consumption, see *Getting to Zero: A Pathway to a Carbon Neutral Seattle* and *Greenhouse Gas Emissions in King County*.[14]

## Disposing of and Recycling Goods and Materials

The majority of Seattle's refuse, also called municipal solid waste (MSW), consists of organic matter. When organic waste is buried in a landfill, a portion decays releasing methane and carbon dioxide, but the remaining portion remains buried in the landfill indefinitely. Table 13 included the emissions of methane under "waste management". The carbon that is not released as methane or $CO_2$ represents carbon storage, since the carbon in the waste was originally extracted from the atmosphere by means such as a food plant, garden vegetation, or a tree harvested for forest products. Table 16 lists the estimated carbon storage from waste disposed in landfills.

Similar to the methane commitment described above, the values in Table 16 are calculated for the waste disposed in the listed calendar year, but represent the storage enduring after that waste's decay is complete, many years in the future.

**Table 16. Carbon storage associated with landfilling of Seattle's municipal solid waste (Metric Tons $CO_2$)**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| Carbon storage | (208,000) | (146,000) | (127,000) | (109,000) |

**Source Notes**
**MSW storage:** Emissions from the management of municipal solid waste for all inventory years were provided by Jenny Bagby, Seattle Public Utilities **(12-50-02)**.

Table 13 and Table 16 include only emissions and carbon storage associated with municipal solid waste generated in Seattle from residents and businesses. Waste from construction and demolition activities

[14] Available online: http://www.seattle.gov/environment/documents/CN_Seattle_Report_May_2011.pdf

also generates emissions. Seattle Public Utilities estimated these for the first time in 2012: 14,000 $tCO_2e$ associated with disposal, and carbon storage of (59,000) $tCO_2$.

### *Emissions avoided from Seattle's recycling program*

Seattle Public Utilities' recycling program results in emissions from its operations, but also avoids emissions associated with disposal of MSW and manufacturing of new materials and products – emissions that largely occur outside Seattle. Table 17, below, presents these estimates, as calculated by Seattle Public Utilities, and assuming that all the material would otherwise have been disposed in a landfill.[15]

In general, the benefit of avoided materials manufacture is significantly more than associated with the recycling infrastructure. In other words, recycling programs yield a significant GHG benefit.

Similarly, composting programs result in both carbon storage and minimal $CO_2$ emissions from transportation and processing. Carbon storage results from the effects of compost application on soil carbon restoration and humus formation.[16]

**Table 17. Emissions avoided from Seattle's recycling program (Metric Tons $CO_2e$)**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| *Emissions* | | | | |
| *Collection* | 4,000 | 6,000 | 6,000 | 11,000 |
| *Processing* | 18,000 | 23,000 | 23,000 | 30,000 |
| *Foregone sequestration* | 197,000 | 205,000 | 205,000 | 180,000 |
| *Avoided emissions* | | | | |
| *Disposal as MSW* | (110,000) | (126,000) | (132,000) | (84,000) |
| *Manufacturing of new materials* | (549,000) | (586,000) | (642,000) | (674,000) |
| ***Emissions totals*** | **(439,000)** | **(478,000)** | **(540,000)** | **(537,000)** |

**Source Notes**

**MSW Sequestration:** Emissions from the management of municipal solid waste for all inventory years were provided by Jenny Bagby, Seattle Public Utilities **(12-50-02)**.

The emissions avoided from recycling construction and demolition waste were estimated by Seattle Public Utilities to be (11,000) t $CO_2e$.

[15] Estimating the avoided emissions that can result from recycling programs (or any other source of avoided emissions) can be challenging, as doing so involves assessing emissions reductions relative to what otherwise would have happened, or to "business as usual". An alternate approach to estimating business-as-usual would be to estimate benefits relative to national average or "common practice" recycling rates.

[16] Composting also emits $CO_2$ from the decomposition of organic source materials, but because these emissions are biogenic, they are not counted toward (anthropogenic) GHG emissions.

### *Closed Landfills*

Landfills continue to emit methane long after they have been closed, although emissions levels drop significantly over time. There are a number of closed landfills in Seattle, and past community inventories included estimates of their methane emissions. For this inventory, waste commitment emissions are highlighted instead of closed landfill emissions. This approach was chosen as recording emissions commitment associated with waste generation reflects the global warming impact of current policy choices much more accurately than the geographic emissions of closed landfills during the same year that arise from waste generated in years not covered by the inventory.

**Table 18. Landfill emissions within Seattle (Metric Tons $CO_2e$)**

| | emissions, $MgCO_2e$ | | | |
|---|---|---|---|---|
| | **1990** | **2005** | **2008** | **2012** |
| *Interbay* | 26,000 | 12,000 | 11,000 | 4,000 |
| *Genesee* | 25,000 | 12,000 | 10,000 | 4,000 |
| *Montlake* | - | 15,000 | 13,000 | 10,000 |
| *Judkins Park* | 4,000 | 2,000 | 2,000 | 1,000 |
| *South Park* | 10,000 | 4,000 | 4,000 | 2,000 |
| *West Seattle* | 6,000 | 3,000 | 2,000 | - |
| ***Totals*** | 71,000 | 48,000 | 42,000 | 21,000 |

**Source Notes**

**Landfills:** Emissions from Interbay, Genessee, Judkins Park, and South Park landfills were estimated using Interbay monitoring data from the portion of the landfill that is under vacuum (7.2% of the landfill surface area). Min-Soon-Yim of Seattle Public Utilities provided the 2012 Interbay monitoring data **(12-50-04)**. For previous inventory years, emissions were updated to reflect the monitoring data reported in file **12-50-04** for consistency.

Emissions from the Montlake landfill for 2008 were calculated using the landfill volume, mass, and the methane kinetics equation from the 2005 University of Washington greenhouse gas inventory **(05-158)**. The calculation steps are the same as for the previous inventory **(08-50-5)**.

No 2012 emissions data for the West Seattle landfill were calculated.

**Uncertainty.** Uncertainty in emissions estimates from closed landfills includes the extent of landfill gas capture. A higher than estimated landfill gas capture rate would mean lower landfill emissions. An additional uncertainty is the rate at which uncaptured methane is oxidized to $CO_2$.

## Appendix A. Description of changes to methodology

This inventory includes some methodological changes compared to the 2008 inventory. These changes are summarized in Table 19.

In addition to the changes summarized in Table 19, small adjustments to the fuel oxidation rates during combustion, from 99% to 100%, and emissions factors based on the latest US EPA national inventory were applied across all sectors. Furthermore, updates to employment totals (Table 22, Appendix C), port tonnage handled (TEUs), and cruise ship port calls were made to reflect the most up-to-date data. One additional correction was made to freight rail emissions, which previously double subtracted a category of overlapping emissions.

**Table 19. Summary of methodological changes from previous inventory calculations.**

| Sector | Subsector | Particular Source | 2008 Method | 2012 Method | Reason for Change |
|---|---|---|---|---|---|
| **Transportation** | | | | | |
| | *Road* | All road except buses | Used VMT data on Seattle roads from SDOT modelling | Used origin-destination pair VMT data from PSRC. Count all intra-city trips, one-half of trips that either begin or end in Seattle; no pass through trips. | Better reflects road transport miles under influence of local policy makers. Has been recently adopted by other jurisdictions, including King County. |
| | *Marine & Rail* | Ferries | Fuel consumed by specific ferries by month | Annual fuel consumption on specific ferry routes | Similar approach with consistent results, but less time-intensive to compile. |
| | | Rail-Passenger | Not included | Included | More comprehensive emissions estimate |
| | | Pleasure Craft | Based on PSCAA NONROAD model output | Based on Department of Ecology NONROAD model output | PSCAA output not available for 2011; PSCAA and Ecology results not similar. |
| | *Air* | Sea-Tac | Attribute emissions from fuel loadings to Seattle based on a one-time survey conducted in August 2001 | Attribute emissions from fuel loadings to Seattle based on Seattle's share of residents and employment in the broader region | Passenger survey was outdated and not robust. New method uses readily available, recent data on population and employment |
| | | King County International Airport | Including emissions associated with landing and Take-off (LTO) only | All jet fuel and aviation gas dispensed on site. | More comprehensive approach that is consistent with treatment of Sea-Tac and with origin-destination pair approach used for road transport |
| **Buildings** | | | | | *No significant changes* |
| **Industry** | | | | | |
| | *Cement* | Process and fuel | 1990 emissions were adjusted upward to compensate for temporary closure of one of Seattle's two cement kilns[17] | Actual production and fuel use for all inventory years | Consistency with treatment for other industrial materials.[18] |
| | *Process* | Glass Production | Not included | Included | More complete emissions estimate. |
| | *Fugitive* | ODS Substitutes | Not included | Included | Are included in national EPA inventory |
| **Waste** | | | | | |

[17] Prior approach was taken to help minimize the influence of factors beyond Seattle's influence (regional or national demand for cement) on Seattle's GHG inventory.
[18] Current approach lacks one key benefit, described in the prior footnote, of the prior method. In future, multiple perspectives, including looking at GHG-intensity, may be employed.

| Sector | Subsector | Particular Source | 2008 Method | 2012 Method | Reason for Change |
|---|---|---|---|---|---|
| | *Landfills* | | In-city landfill emissions during inventory year | Waste commitment associated with landfilled waste produced in-city during inventory year | Waste commitment better reflects emissions associated with current-year policies and programs |

## Appendix B. Source documentation

The formal inventory is a dataset consisting of electronic files. These data files are divided into the following categories:

**Index file** – A single index file, <Community dataset index 12.xlsx>, lists names, descriptions, and sources of all other files in the inventory.

**Source files** – These files are numbered 12-00-00 to 12-90-00. The files are organized by category in the following format:

12-00 Inventory

12-10 Transportation

12-20 Buildings

12-40 Industry

12-50 Waste

12-60 Electricity

12-70 Population & Employment

12-90 Communications

12-800 Reference Docs

**Calculation files** – File 12-00-0 is the master calculation file for the inventory, and includes at least the highest-level calculations for every datum reported in this document. Every table describing the inventory in this document is duplicated from: <12_00_0_Master_Spreadsheet.xlsx>.

Every datum in the calculation files is traceable to one of the source files through the 12-XX-XX number provided in the "call no." column of most of the calculation files. These sources files are listed below in Table 20. In addition, some source files from prior inventory work in Seattle are referenced. These source files are in the format 08-XX-XX (*2008 Seattle Community Greenhouse Gas Inventory*) or 05-XX-XX (*2005 Inventory of Seattle Greenhouse Gas Emissions: Community & Corporate*) and are maintained by the City of Seattle Office of Sustainability & Environment (OSE). Additionally, some source files reference KC08-XX-XX (*Greenhouse Gas Emissions in King County*).

## Table 20. Catalog of Source Documents

| Call# | Subject | Ext. | Document title |
|---|---|---|---|
| **12-00-0** | **Inventory** | | |
| 12-00-0 | Master Spreadsheet | .xlsx | Master_Spreadsheet_X_XX_XX |
| | | | |
| **12-10-0** | **Transportation** | | |
| | | | |
| **12-11-XX** | **Road** | | |
| 12-11-01 | National Transport Statistics Table 4-11 for Passenger vehicles and motorcycles | .xlsx | Passenger_Motorcycle |
| 12-11-02 | National Transport Statistics Table 4-12 for light duty trucks | .xlsx | Light_Trucks |
| 12-11-03 | National Transport Statistics Table 4-13 for single-unit trucks | .xlsx | Single_Unit_Trucks |
| 12-11-04 | National Transport Statistics Table 4-14 for combo trucks | .xlsx | Combo_Trucks |
| 12-11-05 | VMT Calculations | .xlsx | VMT_calcs |
| 12-11-06 | Highway Performance Management System (HPMS) DVMT data for King County from WSDOT | .doc | HPMS_DVMT |
| 12-11-07 | VMT by vehicle type from 2006 base year model | .xlsx | PSRC_VMT_2006 |
| 12-11-08 | VMT by vehicle type from 2011 base year model; VMT in total for 2008 base year model | .xlsx | PSRC_VMT_2011 |
| 12-11-09 | Adjustments to convert average weekday to average daily VMT | .xlsx | Avg_Daily |
| 12-11-10 | Annual VMT for WSDOT roads | .xlsx | WSDOT_State_Highway_VMT |
| 12-11-11 | Adjustments to medium and heavy duty truck VMT figures for 2006 model (12-11-07) | .docx | VMT_corr |
| 12-11-12 | VMT by vehicle type from 2008 base year model | .xlsx | PSRC_VMT_2008 |
| 12-11-13 | King County Metro Bus Fleet 2012 Miles and Fuel | .pdf | busanfleet1212 |
| 12-11-14 | King County Metro Fleet count and miles, 2012 | .xlsx | MoMi2012 |
| 12-11-15 | Bus Emissions Workbook | .xlsx | WKBK Bus emissions |
| **12-12-XX** | **Marine** | | |
| 12-12-01 | Port of Seattle 10-year History | .xlsx | 10yearhistory |
| 12-12-02 | WSF Route Statements and Analysis, FY 2007-2012 (Gives Fuel Costs) | .pdf | WSF_RouteStatementsAndAnalysis |
| 12-12-03 | WA Department of Enterprise Services Biodiesel Use Report | .pdf | WA_DES_BiodieselUseReport |
| 12-12-04 | WA Department of Ecology 2005 NONROAD model output (multiple text files loaded into one workbook) | .xlsx | NONROAD_WA_DoE_2005_Rec_Boat |
| 12-12-05 | US Community Protocol for Accounting and Reporting, Appendix D: Transportation and Other Mobile… | .pdg | ICLEI_Appendix_D_Tansportation_and_Other_Mobile_ Emission |
| **12-13-XX** | **Rail** | | |
| 12-13-01 | Amtrak Energy Intensity per passenger revenue mile | .xls | Amtrak_EnergyIntensity |
| 12-13-02 | 2012 Amtrak Cascades Annual Report | .pdf | AmtrakCascadesAnnualPerformanceReport2012 |
| 12-13-03 | 2011 Amtrak Cascades Annual Ridership Report | .pdf | AmtrakCascadesAnnualRidershipReport2011 |
| 12-13-04 | Historical Amtrak Cascades Ridership and Station On-Off, 1994-2007 | .pdf | Amtrak_station_infoweb07 |
| 12-13-05 | Sound Transit 2012 Sustainability Report | .pdf | SoundTransit2012SustainabilityProgressReport |
| 12-13-06 | Sound Transit 2011 Sustainability Report | .pdf | SoundTransit2011SustainabilityProgressReport |
| 12-13-07 | Sound Transit 2011 NTD Database Profile | .pdf | SoundTransitNTD2011 |
| 12-13-08 | Sound Transit 2008 NTD Database Profile | .pdf | SoundTransitNTD2008 |
| 12-13-09 | Sound Transit 2005 NTD Database Profile | .pdf | SoundTransitNTD2005 |
| 12-13-10 | Sound Transit Regional Transit Long-Range Plan Final SEIS, Section 4.6 | .pdf | SEIS_SoundTransit |
| 12-13-11 | Sound Transit 2012 Q4 Service Delivery Report | .pdf | 2012Q4_QuarterlyServiceDeliveryPerformanceReport |
| **12-14-XX** | **Air** | | |
| 12-14-01 | Sea Tac Emissions Ratio Workbook | .xlsx | SeaTacRatio |
| 12-14-02 | Take Offs and Landings by Aircraft Purpose and Airport | .xlsx | FAA_Take-offs-Landings |
| 12-14-03 | KCIA 2007 GHG Inventory | .pdf | KCIA_GHG_Inventories_20110624 |
| 12-14-04 | KCIA Emissions workbook | .xlsx | KCIA_Workbook |
| 12-14-05 | Sea-Tac annual activity report | .pdf | SeaTac_Activity_Report |
| | | | |
| **12-20-0** | **Buildings** | | |
| **12-20-XX** | **Residential** | | |
| 12-20-01 | Home Heating Type | .xlsx | Home_Heating_ACS |
| 12-20-02 | Natural gas consumption for residential, commercial, industrial sectors, from PSE | .pdf | PSE_nat_gas |
| 12-20-03 | 1990 HDD and CDD for Sea-Tac International Airport Stations | .pdf | 1990_HDD_CDD_SeaTac |
| 12-20-04 | Heating and Cooling Degree Days, Sea-Tac International Airport Station | .xlsx | HDD_CDD |
| **12-30-XX** | **Commercial** | | |
| | | | |
| **12-40-0** | **Industry** | | |
| | | | |
| 12-40-01 | NONROAD model results | .xlsx | NONROAD 2011 |
| 12-40-02 | NONROAD emissions calculations by fuel/sector | .xls | NONROAD_CALCS.xls |
| 12-40-03 | Distillate Fuel and Kerosene Use | .xls | WA_DistillateFuel_Kerosene_Sales_EndUse |
| 12-40-04 | ODS Emissions - EPA Module | .xls | EPA_IP_MODULE |
| 12-40-05 | Point Source Summary | .xls | PointSourceSummary |
| 12-40-06 | Ash Grove 2012 Emissions Report to EPA | .pdf, .txt | AshGrove_EPAEmissions |
| 12-40-07 | LaFarge 2012 Emissions Report to EPA | .txt | LaFarge_EPAEmissions |
| 12-40-08 | Cement Sustainability Initiative "Getting the Numbers Right" US carbon intensity of clinker production | .pdf | CSI_GNR_CementIntensity_UnitedStates |
| 12-40-09 | Cement Statistics, USGS | .xlsx | USCementConsumption |
| 12-40-10 | December 2012 Mineral Industry Surveys - Cement, USGS | .pdf | 2012CementUse |
| 12-40-100 to 115 | Various PSCAA 2012 Facilities Emissions Reports | .pdf, .xls | Various |

## Table 21. Catalog of Source Documents (continued)

| | | | |
|---|---|---|---|
| **12-50-0** | **Waste** | | |
| 12-50-01 | Waste Water Treatment Emissions | .xls | WWT_2011 |
| 12-50-02 | 2012 Seattle MSW GHG Inventory | .xls | SPU_MSW_GHGInventory |
| 12-50-03 | 2012 SPU Construction and Demolition GHG Inventory | .xls | SPU_2012_CDL_GHG Inventory |
| 12-50-04 | 2012 Seattle MDW GHG Inventory | .xls | _GHGInventory_Interbay_MDW |
| 12-50-05 | SPU 3rd Quarter 2013 Garbage Report for Seattle | .pdf | SPU_Nov2013_GarbageReport |
| | | | |
| **12-60-0** | **Electricity** | | |
| 12-60-01 | WA Commerce State aggregate fuel mix time series | .xlsx | WACommercerCO2electricity |
| 12-60-02 | WA Commerce Fuel Mix Disclosure Report | .pdf | 2012FuelMixDisclosure |
| 12-60-03 | SCL and PSE Emissions Factor Calculation | .xlsx | FuelMix_SCL-PSE |
| | | | |
| **12-70-0** | **Population and Employment** | | |
| 12-70-01 | Population Counties 2000-2012 | .xls | Pop_Counties |
| 12-70-02 | Population Counties 1990s | .pdf | Pop_Counties_1990s |
| 12-70-03 | Population | .xls | Pop_Cities |
| 12-70-04 | Employment | .xls | Employment_Counties |
| 12-70-05 | Employment | .xls | Employment_Cities |
| 12-70-06 | Employment | .xls | Employment_King |
| 12-70-07 | Employment | .xls | Employment_Kitsap |
| 12-70-08 | Employment | .xls | Employment_Pierce |
| 12-70-09 | Employment | .xls | Employment_Snohomish |
| 12-70-10 | Employment | .pdf | 1998AnnualGrowthReport_KING |
| 12-70-11 | Employment | .xlsx | Employment |
| 12-70-12 | Employment | .pdf | CoveredEmployment_Seattle |
| 12-70-13 | State Populations 2000-2012 | .xls | Pop_States_2000s |
| 12-70-14 | State Populations 1990s | .pdf | Pop_States_1990s |
| 12-70-15 | Seattle DPD Population and Demographics | .html | SeattleDPD_Population |
| 12-70-16 | Seattle DPD Employment Data | .pdf | DPD_Seattle_Employment_2012 |
| 12-70-100 | 2005 Annual Average of Quarterly Census Employment and Wages (QCEW) | .xls | 2005QCEW |
| 12-70-101 | 2008 Annual Average of Quarterly Census Employment and Wages (QCEW) | .xls | 2008QCEW |
| 12-70-102 | 2011 Annual Average of Quarterly Census Employment and Wages (QCEW) | .xls | 2011QCEW |
| 12-70-103 | 2012 Annual Average of Quarterly Census Employment and Wages (QCEW) | .xls | 2012QCEW |
| | | | |
| **12-80x** | **Reference Docs** | | |
| 12-801 | US GHG Inventory 2013, Annex 2, Emissions from fossil fuel combustion | .pdf | US-GHG-Inventory-2013-Annex-2-Emissions-from-Fossil-Fuel-Combustion |
| 12-802 | US GHG Inventory 2013, Main Report | .pdf | US-GHG-Inventory-2013-Main-Text |
| 12-803 | Puget Sound Maritime Air Emissions Inventory, May 2013 Update | .pdf | EI_Full_Report |

## Appendix C. Population information

In several cases it was necessary to estimate emissions by scaling by population or employment from other years, or from the state to county level. The population figures used in these estimates are listed in Table 22 below.

**Table 22: Population Geographic Region and Employment Type**

| | 1990 | 2005 | 2008 | 2012 |
|---|---|---|---|---|
| **Seattle** | | | | |
| *Residents* | 516,259 | 573,336 | 593,588 | 634,535 |
| *Commercial Employees* | 363,932 | 417,057 | 440,295 | 441,042 |
| *Industrial Employees* | 58,147 | 45,879 | 55,106 | 41,356 |
| **King County** | | | | |
| *Residents* | 1,517,208 | 1,795,268 | 1,875,020 | 2,007,440 |
| *Commercial Employees* | - | 948,453 | 1,005,634 | 1,009,746 |
| *Industrial Employees* | - | 165,424 | 181,195 | 150,982 |
| **Washington** | | | | |
| *Residents* | 4,903,043 | 6,257,304 | 6,562,231 | 6,897,012 |
| *Commercial Employees* | - | 2,243,114 | 2,383,847 | 2,384,842 |
| *Industrial Employees* | - | 432,773 | 473,002 | 407,180 |

**Source Notes**

**Population:** Resident populations were acquired from the U.S Bureau of the Census Population Estimates Program (www.census.gov/popest/). Population estimates can be found in **12-70-03** (Seattle), **12-70-01** and **12-70-02** (King County), and **12-70-13** and **12-70-14** (Washington State). Seattle Population in 1990 was taken from the Seattle Department of Planning and Development website **(12-70-15)**.

**Employees:** King County and Washington State employees were obtained from Annual Averages of the Quarterly Census of Employment and Wages (QCEW) available through the Washington State Employment Security Department **(12-70-100** to **12-70-103)**. Covered Employment for Seattle for 2005, 2008, and 2012 come from the Seattle Department of Planning and Development (DPD) (**12-70-16)**. All employment data are tabulated in workbook **12-70-11**. Industrial employees are taken as the sum of manufacturing and construction covered employment and commercial employees are the remainder less agriculture, forestry, fishing, and hunting.

# Appendix D. Detailed tracking metrics

The table below presents detailed metrics that may be useful for tracking trends in underlying drivers that affect Seattle's core emissions.

| Emissions Source | | 1990 | 2005 | 2008 | 2012 | Change, 1990 to 2012 | Change, 2008 to 2012 |
|---|---|---|---|---|---|---|---|
| | Population | 516,259 | 573,336 | 593,588 | 634,535 | 23% | 7% |
| **Core** | | | | | | | |
| Transportation: Road | | | | | | | |
| | Emissions (Million MT CO2e) | 2.2 | 2.3 | 2.3 | 2.4 | 9% | 6% |
| | Emissions per person (MT $CO_2$e/resident) | 4.3 | 4.0 | 3.8 | 3.8 | -11% | -1% |
| | Passenger emissions per person (MT $CO_2$e/resident) | 3.0 | 2.8 | 2.7 | 2.6 | -13% | -1% |
| | Freight emissions per person (MT CO2e/resident) | 1.2 | 1.2 | 1.1 | 1.1 | -8% | 0% |
| | Passenger VMT (billion miles) | 3.42 | 3.89 | 3.98 | 4.12 | 20% | 3% |
| | Freight Truck VMT (billion miles) | 0.37 | 0.43 | 0.44 | 0.46 | 22% | 4% |
| | Passenger VMT/person (thousand miles/resident) | 6.6 | 6.8 | 6.7 | 6.5 | -2% | -3% |
| | Freight Truck VMT/person (thousand miles/resident) | 0.7 | 0.7 | 0.7 | 0.7 | -1% | -3% |
| | VMT (billions miles) | 3.8 | 4.3 | 4.4 | 4.6 | 20% | 3% |
| | VMT per capita (thousand miles/resident) | 7.4 | 7.5 | 7.4 | 7.2 | -2% | -3% |
| | Emissions per mile (kgCO2e/VMT) | 0.58 | 0.53 | 0.51 | 0.52 | -10% | 2% |
| | Passenger emissions per mile (kgCO2e/VMT) | 0.46 | 0.42 | 0.40 | 0.41 | -11% | 2% |
| | Freight truck emissions per mile (kgCO2e/VMT) | 1.70 | 1.60 | 1.54 | 1.58 | -7% | 2% |
| Buildings: Residential & Commercial | | | | | | | |
| | Emissions (Million MT CO2e) | **1.5** | **1.3** | **1.4** | **1.2** | -15% | -10% |
| | Residential Emissions (Million MT CO2e) | 0.7 | 0.6 | 0.6 | 0.5 | -25% | -11% |
| | Commercial Emissions (Million MT CO2e) | 0.7 | 0.7 | 0.8 | 0.7 | -5% | -8% |
| | Emissions per capita (MT $CO_2$e/resident) | 2.8 | 2.2 | 2.3 | 2.0 | -31% | -15% |
| | Residential emissions per capita (MT $CO_2$e/resident) | 1.4 | 1.0 | 1.0 | 0.8 | -39% | -17% |
| | Commercial emissions per capita (MT $CO_2$e/resident) | 1.4 | 1.2 | 1.3 | 1.1 | -23% | -14% |
| | Residential Energy use (PJ) | 21.6 | 20.3 | 19.4 | 18.4 | -15% | -5% |
| | Natural gas | 5.2 | 7.4 | 8.6 | 8.4 | 62% | -3% |
| | Heating oil | 4.7 | 1.9 | 1.9 | 1.3 | -73% | -32% |
| | Electricity | 11.7 | 11.1 | 8.9 | 8.8 | -25% | -1% |
| | Commercial energy use (PJ) | 22.4 | 28.1 | 29.4 | 29.0 | 29% | -1% |
| | Natural gas | 5.6 | 7.0 | 8.0 | 8.0 | 42% | 0% |
| | Heating oil | 2.0 | 1.2 | 1.5 | 1.3 | -34% | -14% |
| | Steam | 2.9 | 3.2 | 3.5 | 3.1 | 6% | -11% |
| | Electricity | 11.8 | 16.7 | 16.4 | 16.6 | 40% | 1% |
| | Energy use (PJ) | 44.0 | 48.4 | 48.8 | 47.4 | 8% | -3% |
| | Residential energy per capita (GJ/resident) | 41.9 | 35.4 | 32.6 | 29.0 | -31% | -11% |
| | Commercial energy per employee (GJ/employee) | 61.6 | 67.4 | 66.8 | 65.7 | 7% | -2% |
| | Heating degree days (HDD) | 4,840 | 4,489 | 5,062 | 4,738 | -2% | -6% |
| | Cooling degree days (CDD) | 250 | 164 | 195 | 181 | -28% | -7% |
| | Energy use per capita per heat demand (GJ per capita per 1000 HDD) | 8.6 | 7.9 | 6.4 | 6.1 | -29% | -5% |
| | Residential GHG intensity of energy (kg $CO_2$e/GJ) | 33.4 | 28.1 | 31.4 | 29.2 | -13% | -7% |
| | Commercial GHG intensity of energy (kg $CO_2$e/GJ) | 33.2 | 24.8 | 26.1 | 24.3 | -27% | -7% |
| Waste: Waste management | | | | | | | |
| | Emissions (Million MT CO2e) | **0.12** | **0.12** | **0.11** | **0.09** | -22% | -17% |
| | Emissions per capita (MT CO2e/resident) | 0.24 | 0.22 | 0.19 | 0.15 | -37% | -23% |
| | Residential waste (tons) | 140,528 | 134,557 | 127,219 | 111,420 | -21% | -12% |
| | Residential waste per capita (tons / resident) | 0.27 | 0.23 | 0.21 | 0.18 | -35% | -18% |
| | Nonresidential waste (tons) | 317,317 | 306,345 | 267,685 | 204,563 | -36% | -24% |
| | Nonresidential waste per capita (tons / employee) | 0.61 | 0.53 | 0.45 | 0.32 | -48% | -29% |
| | Emissions per ton disposed (MT CO2e/ton) | 0.87 | 0.92 | 0.90 | 0.85 | -2% | -6% |
| **Total** | | | | | | | |
| | **Emissions (Million MT CO2e)** | **3.8** | **3.7** | **3.7** | **3.7** | **-1%** | **0%** |
| | **Emissions per capita (MT CO2e/resident)** | **7.3** | **6.5** | **6.3** | **5.9** | **-20%** | **-7%** |

## Appendix E. Community GHG emissions summary (ICLEI-US Format)

The table on the following page lists emissions sources and activities addressed in the ICLEI-USA protocol and describes whether they are included or not, in accordance with that protocol's requirements.

| Emissions Type | Included, Main Inventory **Table** (Bold if required) | Included, Supplemental Calculations | Excluded (Reason) | Explanatory Notes | Emissions (Metric tons CO2e) |
|---|---|---|---|---|---|
| **Built Environment** | | | | | |
| Use of fuel in residential and commercial stationary combustion equipment | **X** | | | We include $CO_2$ emissions from natural gas and oil use because they are straight-forward to calculate but do not include associated $CH_4$ or $N_2O$ emissions since they are small and relatively uncertain and including them would not significantly change the relative magnitude of different sources | 1,006,000 |
| Industrial stationary combustion sources | X | | | See first row above for notes on $CH_4$ or $N_2O$. | 478,000 |
| Power generation in the community | | | X (Not Occurring) | No major power generators in the city; small sources included to extent fuels use data includes fuels used to generate electricity | N/A |
| Use of electricity by the community | **X** | | | Emissions associated with production of electricity for consumption by users in city are offset with certified carbon offset purchases by the local public utility, Seattle City Light | 91,000 |
| District heating/cooling facilities in the community | X | | | Steam generation emissions. | 156,000 |
| Use of district heating/cooling by the community | | | X (Included elsewhere | Same as above, as no district heating or cooling facilities from outside the geographic boundary serve the community. | N/A |
| Industrial process emissions in the community | X | | | Includes emissions associated with cement, steel, and glass production | 346,000 |
| Refrigerant leakage in the community | X | | | Estimated using US EPA's State Inventory Tool for ozone depleting substance (ODS) substitutes, then scaled to Seattle | 235,000 |
| **Transportation and Other Mobile Sources** | | | | | |
| On-road passenger vehicles operating within the community boundary | | | X (Included elsewhere) | Calculated using origin-destination pair method instead (immediately below) | N/A |
| On-road passenger vehicle travel associated with community land uses | **X** | | | | 1,603,000 |
| On-road freight and service vehicles operating within the community boundary | | | X (Included elsewhere | Calculated using origin-destination pair method instead (immediately below) | N/A |
| On-road freight and service vehicle travel associated with community land uses | **X** | | | | 720,000 |

| | | | | | |
|---|---|---|---|---|---|
| On-road transit vehicles operating within the community boundary | X | | | Calculated from transit vehicle fuel use associated with VMT within city limits | 66,000 |
| Transit rail vehicles operating within the community boundary | | | X (Included elsewhere) | Calculated using origin-destination pair method instead (immediately below) | N/A |
| Use of transit rail travel by the community | X | | | Calculated using origin-destination pair method | 12,000 |
| Inter-city passenger rail vehicles operating within the community boundary | | | X (Included elsewhere) | Calculated using origin-destination pair method instead (immediately above). | N/A |
| Freight rail vehicles operating within the community boundary | X | | | | 53,000 |
| Marine vessels operating within the community Boundary | X | | | Includes emissions associated with hoteling, pleasure craft, and other ship & boat traffic | 110,000 |
| Use of ferries by the community | X | | | | 42,000 |
| Off-road surface vehicles and other mobile equipment operating within the community boundary | X | | | Includes residential yard equipment and commercial equipment fuel combustion based on NONROAD modeling efforts from the state Department of Ecology | 181,000 |
| Use of air travel by the community | X | | | Includes all reported fuel loadings at King County International Airport (in city boundaries) and a share of fuel loadings from Sea-Tac airport (outside city boundaries) based on population and employment | 905,000 |
| **Solid Waste** | | | | | |
| Operation of solid waste disposal facilities in the Community | | X | | Annual emissions from in-city landfills. | (21,000) |
| Generation and disposal of solid waste by the community | **X** | | | Waste management emissions associated with collection, transfer & long haul, and commitment to landfill emissions | 95,000 |
| **Water and Wastewater** | | | | | |
| Operation of water delivery facilities in the community | | | X (Included elsewhere) | Included by default as part of community energy use, but not specifically listed | N/A |
| Use of energy associated with use of potable water by the community | | | **X** (Included elsewhere) | Included by default as part of community energy use, but not specifically listed | N/A |
| Use of energy associated with generation of wastewater by the community | | | **X** (Included elsewhere) | Included by default as part of community energy use, but not specifically listed Nothing for energy use. | N/A |
| Process emissions from operation of wastewater treatment facilities located in the community | X | | | | 2,000 |
| Process emissions associated with generation of wastewater by the community | | | X (Included elsewhere) | Very similar to above, except that territory of the in-city facility does not exactly match that of the city's boundaries | N/A |
| Use of septic systems in the community | | | X (de minimis) | Very few septic systems in-city | N/A |
| **Agriculture** | | | | | |
| Domesticated animal production | | | X (de minimis) | Very little, if any, livestock raising in-city | N/A |
| Manure decomposition and treatment | | | X (de minimis) | Very little, if any, livestock raising in-city | N/A |

| | | | | | |
|---|---|---|---|---|---|
| **Upstream Impacts of Community-Wide Activities** | | | | | |
| Upstream impacts of fuels used in stationary applications by the community | | | X (de minimis) | Would introduce significant uncertainty to inventory without changing directionality of results. Use of fuels with significant upstream impacts (e.g. biofuels) minimal at this time | N/A |
| Upstream and transmission and distribution (T&D) impacts of purchased electricity used by the community | | | X (Included elsewhere) | Included in emissions associated with electricity consumption | N/A |
| Upstream impacts of fuels used for transportation in trips associated with the community | | | X (de minimis) | Would introduce significant uncertainty to inventory without changing directionality of results. Use of fuels with significant upstream impacts (e.g. biofuels) minimal at this time | N/A |
| Upstream impacts of fuels used by water and wastewater facilities for water used and wastewater generated within the community boundary | | | X (de minimis) | Would introduce significant uncertainty to inventory without changing directionality of results. Use of fuels with significant upstream impacts (e.g. biofuels) minimal at this time | N/A |
| Upstream impacts of select materials (concrete, food, paper, carpets, etc.) used by the whole community. Note: Additional community-wide flows of goods & services will create significant double counting issues. | | | X (included elsewhere) | Counted using consumption-based accounting (below) | N/A |
| **Independent Consumption-based Accounting** | | | | | |
| Household Consumption (e.g., gas & electricity, transportation, and the purchase of all other food, goods and services by all households in the community | | X | | Based on 25 mtCO2e per person and the community population in 2012. | 15,860,000 |
| Government Consumption (e.g., gas & electricity, transportation, and the purchase of all other food, goods and services by all governments in the community) | | | X (Included elsewhere | Included in household consumption emissions (above) | N/A |
| Life cycle emissions of community businesses (e.g., gas & electricity, transportation, and the purchase of all other food, goods and services by all businesses in the community) | | | X (Not applicable) | Inconsistent with consumption-based method that assigns emissions to final consumers; is included to extent community businesses fulfill final consumption by Seattle residents or government | N/A |