City of Seattle Municipal Greenhouse Gas Emissions Inventory

2008- 2009

Office of Sustainability & Environment, City of Seattle August 2011

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Municipal Operations Emissions Summary

In 2005, the City of Seattle made climate change a priority by committing to reduce greenhouse gas (GHG) emissions from both citywide sources and municipal operations. To track progress toward this goal, the Office of Sustainability & Environment (OSE) produced an inventory of emissions from 2005 municipal operations. The inventory is the City's primary way of gauging progress toward meeting Seattle's near and long-term goals of reducing climate pollution, and highlights where emissions are increasing and decreasing. OSE recently completed municipal operations inventories for 2008 and 2009.

This inventory measures the GHG emissions from operations and from areas where the City can exert policy influence, including the following eight sectors: City Light Electricity Generation, Solid Waste Landfills, Buildings and Facilities, Employee Commutes, City-owned Vehicles, Government Generated Solid Waste, Employee Air Travel, and Street Lights and Traffic Signals. The results of the inventory (Figure 1, Table 1) show that the City of Seattle's largest source of emissions is from energy purchased through contracts by Seattle City Light (SCL), followed by emissions from the City's vehicle fleet, buildings and facilities, and closed landfills. Although emissions from electricity generation are the largest source of emissions for the City of Seattle, SCL offsets these emissions by investing in carbon reduction projects, effectively zeroing out the carbon footprint of electricity in Seattle.

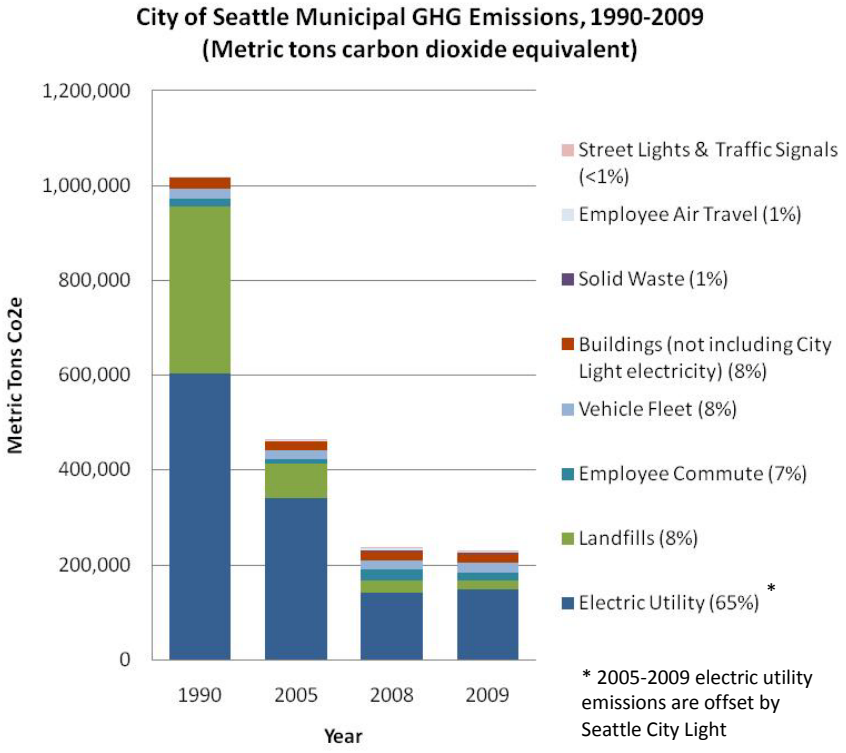

Figure 1 Overview of Municipal GHG Inventory 1990-2009

Table 1 Emissions from Municipal Operations by Sector, 1990 to 2009[1]

Municipal GHG Emissions by Sector	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009
Electric Utility						
Owned generation	594,000	-	-	-	-100%	-
Switchgear insulation	10,000	5,320	1,810	1,860	-81%	-65%
Transmission and distribution losses	n.d.	n.d.	2,360	2,520	-	-
Purchased generation	93,200	335,000	136,000	145,000	56%	-57%
Total	**604,000**	**341,000**	**140,000**	**149,000**	-75%	-56%
Buildings						
Natural gas heating	20,900	14,900	15,500	15,300	-27%	-
Refrigerant loss	n.d.	13	12	40	-	208%
Electricity (Puget Sound Energy)	n.d.	4,230	1,320	1,450	-	-66%
Steam	740	175	219	196	-74%	12%
Total	**21,600**	**19,300**	**17,000**	**17,000**	**-21%**	**-12%**
*Electricity consumption (City Light)**	*n.d.*	*3,030*	*3,210*	*3,850*	-	-
Vehicles						
Gasoline	13,400	12,200	12,700	12,100	-10%	-1%
Diesel	6,060	2,950	2,050	7,510	24%	155%
Biodiesel	-	4,210	5,880	2,380	-	-43%
CNG	220	117	54	28	-87%	-76%
Liquid Propane Gas	80	44	-	-	-	-
Unknown vehicles	3,500	2,280	-	-	-	-
Refrigerants	n.d.	44	-	-	-	-
Total	**23,200**	**21,800**	**20,700**	**22,100**	-5%	1%
Waste						
Landfills	351,000	73,400	65,300	44,300	-87%	-40%
Employee solid waste						
Recycling and composting	n.d.	n.d.	639	531	-	-
Disposal (collection, transfer, and landfill)	n.d.	n.d.	2,820	2,530	-	-
Total	**351,000**	**73,400**	**68,800**	**47,400**	**-86%**	**-35%**
Other Emissions						
Employee commuting	n.d.	9,170	7,590	7,700	-	-16%
Business air travel	5,060	2,330	2,800	2,360	-53%	1%
Total	**5,060**	**11,500**	**10,400**	**10,100**	-	**-12%**
Optional Information						
MSW-related sequestration	n.d.	(3,300)	(3,200)	(3,200)		-3%
Recycling emissions	n.d.	(17,300)	(14,900)	(14,900)		-14%
Total Emissions	**1,004,860**	**467,000**	**256,900**	**245,600**	**-76%**	**-47%**

All units are Metric Tons Carbon Dioxide Equivalent, rounded to the nearest hundred.

**City Light electricity from building operations and street lights are not included in the inventory total because these emissions are accounted for in the electric utility sector.*

Emissions by Sector

The pie chart below shows the percentage of emissions generated by sector for municipal operations in 2009, including emissions from City buildings, vehicle fleet, employee commutes, air travel, employee generated solid waste, and street lights and traffic signals. Only the portion of City Light emissions associated with electricity consumed by City buildings is included in the chart.

[1] The totals and sub-totals listed in the tables and in this report are not to represent all-inclusive, complete totals for Seattle's operations. These "totals" are only a summation of inventoried emissions using best-available estimation methods. Reporting as a total can be misleading as each inventoried sector may have additional emissions sources associated with them that were unaccounted for, such as Scope 3 sources that could not be estimated. Additionally, reporting a "roll-up" total for multiple sectors can be misleading, as emissions from different scopes can be double-counted when they are reported as one number. For example, if emissions from the Buildings and Municipal Power Generation sectors were reported as a single number, emissions would be double counted, since Seattle City Light provides electricity to most government buildings.

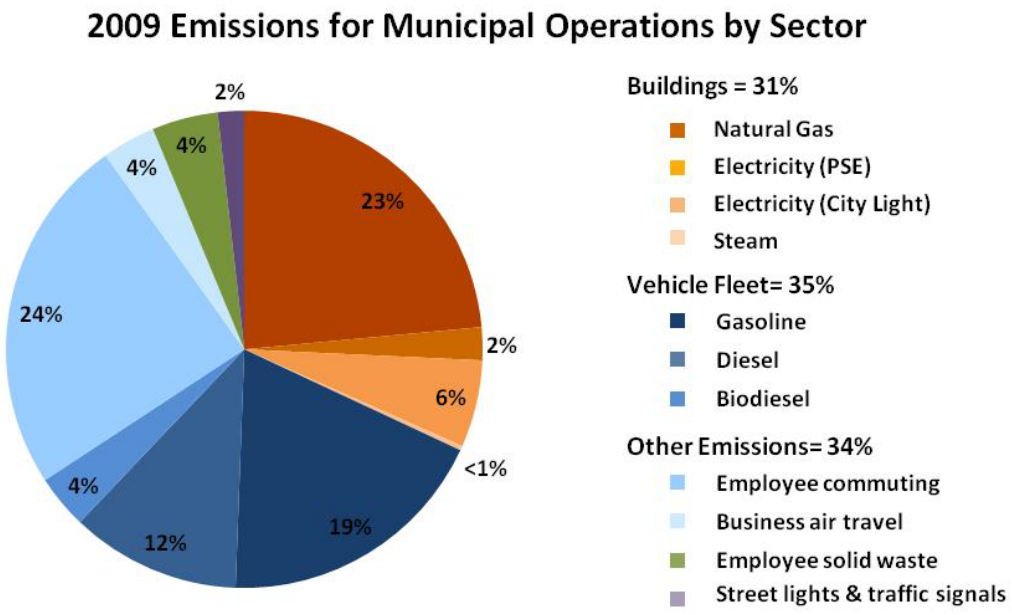

Figure 2 2009 Emissions for Municipal Operations by Sector

Emissions Trends

The following section describes trends in emissions and highlights select Seattle's municipal emission reduction efforts. The arrows indicate whether emissions are increasing, decreasing, or staying the same since 1990.

↓ **Electricity Generation:** The majority of the City of Seattle's emissions come from Seattle City Light contracts for power needs beyond the City's own hydroelectric-generation capacity. The generation owned by City Light remains entirely renewable, but the carbon content of the electricity purchased through contracts has changed. Emissions declined 44% from 1990 to 2005 as a result of City Light ending its partial ownership of the Centralia coal-fired power plant. From 2005 to 2009, emissions declined an additional 56%, due in large part to the end of a contract to purchase electricity from a plant powered by natural gas. Emissions increased from 2008 to 2009 by 6% due to an increase in the carbon content of electricity contracts (Figure 1).

↑ **Vehicle Fleet:** Overall, vehicle fleet emissions, which comprise approximately 35% of municipal emissions when electricity generation and closed landfills are not included, have increased by only 1% from 1990 to 2009. Emissions decreased by about 7% from 1990 to 2008 due to an increase in biodiesel in place of regular diesel, and have increased by about the same amount in the past year due to a decrease in biodiesel consumption. The City reduced biodiesel consumption because of uncertainties in the climate change benefits of the fuel. While total emissions have increased from 2008 to 2009, gasoline consumption decreased by 4%, or by 60,400 gallons. This reduction can be attributed to increased use of high-efficiency gasoline-

electric hybrid vehicles, as well as efforts across City departments to carpool, to reduce unnecessary trips, and to use the most efficient vehicle possible.

- **Solid Waste Landfills:** Many people may be surprised to learn that one of the largest sources of emissions for the City of Seattle is garbage that lives on in the form of methane released by decomposing waste in the six now-closed Seattle landfills. The good news is since the landfills are no longer accepting waste, the emissions will continue to decline over time as materials in the landfill further degrade. Since 2005, the amount of methane released from closed landfills owned by the City has declined by 40%. Methane production in landfills typically begins 6 to 12 months after waste placement, rises to a maximum shortly after landfill closure and gradually declines over a period of 30-50 years.

- **Buildings & Facilities:** City buildings and facilities contribute to GHG emissions from electricity and natural gas consumption for heating, cooling, and lighting. Since 2005, building emissions have decreased by 10%. The City has taken considerable steps to reduce the carbon footprint of City-owned facilities, and is in the process of identifying areas where energy efficiency can be improved. For more information, visit www.seattle.gov/environment/built.htm.

- **Employee Commute:** Employee commute emissions include the emissions from personal and vanpool vehicles for sites with over 100 employees, and have decreased since 2005. Commute emissions from 2009 totaled about 7,700 metric tons of GHG emissions, and roughly 84% of these emissions were from drive-alone commute trips. Work sites outside of downtown Seattle have the highest per-employee emissions, due to the fact that these areas are not well-served by transit.

- **Government Generated Waste:** The inventory also includes estimated emissions from solid waste generated by City employees at work, such as paper and other waste from offices and construction. Although the estimate of emissions from Government Generated Solid Waste shows an 11% decrease in waste disposal volumes, this calculation is based on an assumed share of waste from citywide waste collection estimates rather than direct measurement, and therefore may not necessarily indicate a reduction in government-generated volumes.

- **Air Travel:** Emissions from employee air travel contribute over 2,000 metric tons of carbon dioxide per year. From 2005 to 2009, air travel has decreased by 8%, mostly likely due to the decrease in funds available for City travel. Since 2007, the City has purchased carbon credits to offset the emissions produced from air travel. These offsets fund local projects that reduce carbon emissions in the Seattle area.

- **Traffic Signals & Streetlights:** Since 2005, the amount of emissions produced by the City's 82,000 streetlights and 1,000 traffic signals has decreased by close to 50% from 2,300 metric tons to 1,200 tons of carbon dioxide, primarily due to lower emission electricity sources. The

City is currently upgrading the high-pressure sodium streetlights to energy-efficient LED lights, which will result in continued emissions reductions. In 2010, City Light replaced over 5,000 lights, and will upgrade an additional 40,000 lights by 2014. These upgrades will reduce energy consumption by 40% compared to current lights.

Methodology

The 2008 and 2009 inventory is part of a commitment on the part of the City of Seattle to measure the municipal carbon footprint annually. The last government operations inventory reported 2005 emissions. This inventory follows similar methodology to the 2005 effort, but is updated to reflect the local government specific GHG accounting protocol called the Local Government Operations Protocol (LGO Protocol), which was released in 2008 and was not in effect when the 2005 inventory was completed. Deviations from previous methods are noted in the sections where the changes occurred.

Local Government Operations Protocol

In 2008, the California Air Resources Board, the California Climate Action Registry, The Climate Registry, and ICLEI – Local Governments for Sustainability USA partnered to develop the LGO Protocol. The purpose of LGO Protocol is to provide the principles, approach, methodology, and procedures needed to develop a local government operations greenhouse gas emissions inventory.

While the LGO Protocol standardizes inventories from government operations, it does not seek to be a wholly accurate inventory of all emissions sources, as certain sources are currently excluded or otherwise impossible to accurately estimate. This and all emissions inventories represent a best estimate of emissions using best available data and calculation methodologies; it does not provide a complete picture of all emissions resulting from the City's operations, and emissions estimates are subject to change as better data and calculation methodologies become available in the future.

Greenhouse Gases and Carbon Dioxide Equivalent

In accordance with LGO Protocol recommendations, this inventory calculates and reports all six internationally recognized greenhouse gases regulated under the Kyoto Protocol (Carbon Dioxide, Methane, Nitrous Oxide, Hydrofluorocarbons, Perfluorocarbons, and Sulfur Hexafluoride). Emissions summaries found throughout this report combine emissions from the various greenhouse gases into carbon dioxide equivalent, CO_2e. Since equal quantities of each greenhouse gas influence global warming to a different degree, converting all emissions to CO_2e allows for comparisons between sectors or departments that can assist local policy setting. Greenhouse gas emissions are reported in this inventory as metric tons of CO_2e ($MgCO_2e$).

The global warming potential (GWP) of common greenhouse gases are outlined in the table below. GWP is a measure of the amount of warming a greenhouse gas may cause, measured against the amount of warming caused by carbon dioxide.

Table 2 Greenhouse Gases and Associated Global Warming Potential

Gas	Chemical Formula	Global Warming Potential
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
Hydroflourocarbons	$C_xH_yF_z$	Various
Perfluorocarbons	C_yG_y	Various
Sulfur Hexafluoride	SF_6	23,900

The Scopes Framework

This inventory reports greenhouse gas emissions by sector, and additionally by "scope", in line with the LGO Protocol and World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) GHG Protocol Corporate Standard (insert endnote). Scopes are defined as follows:

Scope 1: Direct emissions from sources within a local government's operations that it owns and/or controls, with the exception of direct CO_2 emissions from biogenic sources. This includes stationary combustion to produce electricity, steam, heat, and power equipment; mobile combustion of fuels; process emissions from physical or chemical processing; fugitive emissions that result from production, processing, transmission, storage and use of fuels; leaked refrigerants; and other sources.

Scope 2: Indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling.

Scope 3: All other emissions sources that hold policy relevance to the local government that can be measured and reported. This includes all indirect emissions not covered in Scope 2 that occur as a result of activities within the operations of the local government. Scope 3 emission sources include (but are not limited to) tailpipe emissions from employee commutes, employee business travel, and emissions resulting from the decomposition of government-generated solid waste.

Organizational Boundaries

The organizational boundary for the inventory determines which aspects of operations are included in the emissions inventory, and which are not. Under the LGO Protocol, two control approaches are used for reporting emissions: operational control or financial control. A local government has operational control over an operation if it has full authority to introduce and implement its operating policies at the operation. A local government has financial control if the operation is fully consolidated in financial accounts. If a local government has joint control over an operation, the contractual agreement will have to be examined to see who has authority over operating policies and implementation, and thus the responsibility to report emissions under operational control.

The LGO Protocol strongly encourages local governments to utilize operational control as the organization boundary for a government operations emissions inventory. Operational control is believed to most accurately represent the emissions sources that local governments can most directly influence, and this boundary is consistent with other environmental and air quality reporting program requirements. For this reason, this inventory was conducted according to the operational control framework.

Inventory Report

The City of Seattle Municipal inventory is divided into the following sections: Buildings and Facilities, Vehicle Fleet, Street Lights and Traffic Signals, Government Generated Solid Waste, Solid Waste Landfills, Municipal Power Generation, Employee Commute, Employee Air Travel, and Offsets and Other Information. Each sector includes emissions totals and source of emissions. A description of the calculation methodologies, an index of source documents, emission factors, and other information, can be found in the Appendix.

1 – Municipal Power Generation

Emissions from the Municipal Power Generation sector result from fuels consumed for the production of electricity. Seattle City Light, a department of the City of Seattle, is one of the nation's largest municipally owned utilities in terms of the number of customers served. The power generation facilities operated by City Light are hydroelectric. In years with normal precipitation, City Light hydroelectric production supplies more than half of Seattle's power needs. The difference is made up by purchasing power from other sources. The overall resource mix is over 90 percent hydroelectric, resulting in very low emissions.

The direct emissions from Seattle City Light operations are summarized in Table 3, and include emissions from owned generation, purchased generation, losses in transmission and distribution, and emissions from leakage of sulfur hexafluoride (SF_6), a gaseous insulator used in electrical switchgear. Each year, a certain quantity of SF_6 must be replaced due to leakage. SF_6 has an extremely high global warming potential of 23,000, so even the small leaked quantity makes a measurable contribution to greenhouse gas emissions. Emissions from Municipal Power Generation are Scope 1 emissions.

In 1990, Seattle had partial ownership in the Centralia coal plant, which generated all of the 528,000 metric tons Co2e emissions listed below. The City sold its ownership of the plant in mid-2000, so in 2005, all remaining generation facilities owned by SCL were hydroelectric and there are zero emissions from owned generation. The decline in emissions from 2005 to 2008 is due primarily to the ending of the Klamath Falls contract, which provided electricity generated from a natural gas fired plant. SCL replaced the contract with lower-emissions sources of electricity, including wind and hydroelectric sources.

Table 3 Municipal Power Generation by Source

	Electricity Generation, MWh				Emissions, $MgCO_2e$					
Source	1990	2005	2008	2009	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009
Owned Generation	8,230,000	5,544,800	4,515,900	4,520,400	594,000	-	-	-	-	-
Purchased Generation	-	6,381,100	5,849,100	5,658,300	-	335,200	136,300	144,700	-	-57%
Transmission & Distribution Losses	n.d.	-	-	-	n.d.	n.d.	2,400	2,500	-	-
SF_6	-	-	-	-	10,000	5,300	1,800	1,900	-81%	-64%
Totals	8,230,000	11,925,900	10,365,000	10,178,600	604,000	340,600	140,500	149,100	-75%	-56%

2 – Buildings and Facilities

The operation of buildings contributes to greenhouse gas emissions in two major ways: from consumption of electricity and fuels such as natural gas, and from leakage of materials used for fire suppression, air conditioning, and refrigeration equipment, which emit hydroflourocarbons (HFCs) and other greenhouse gas emissions. The majority of emissions are from electricity and natural gas consumption.

City of Seattle building emissions include both Scope 1 and Scope 2 emissions: the direct combustion of natural gas and leaked refrigerants are Scope 1 and the electricity and steam consumption are Scope 2 emissions. The changes between 2008 and 2009 are mainly attributable to a 1,000 metric ton increase in emissions from Fleets & Administrative Services, and a 500 metric ton decline in emissions from Seattle Center. These totals are driven by changes in weather, square footage, and energy-efficiency upgrades.

The increase in natural gas usage from 2005 to 2009 is mostly likely due to an increase in building square footage and colder winter weather, although comprehensive data on changes in square footage for City facilities since 2005 is not available (Table 4).

Table 4 1990- 2009 Buildings & Facilities Emissions by Source

	Energy Consumption				Emissions (MgCo2e)					
Energy Type	**1990**	**2005**	**2008**	**2009**	**1990**	**2005**	**2008**	**2009**	**% change 1990-2009**	**% change 2005-2009**
PSE Electricity (MWh)	n.d.	11,000	13,940	13,920	n.d.	4,230	1,320	1,800	-	-57%
Natural Gas (Th)	3,422,440	2,772,050	2,925,450	2,829,220	20,880	14,890	15,450	15,310	-27%	3%
Steam (MLBs)	n.d.	1,890	1,770	1,480	740	175	220	200	-73%	14%
SCL Electricity (MWh) [2]	*n.d.*	*105,930*	*154,730*	*168,830*	*n.d.*	*6,420*	*1,690*	*2,050*	-	*-68%*
Total					21,620	19,290	16,990	17,310	-20%	-10%

The following chart (Figure 3) shows total emissions from City of Seattle buildings and facilities by energy type. The majority of building emissions are from natural gas use, followed by emissions from electricity use, and only a very small percentage of emissions are from steam consumption.

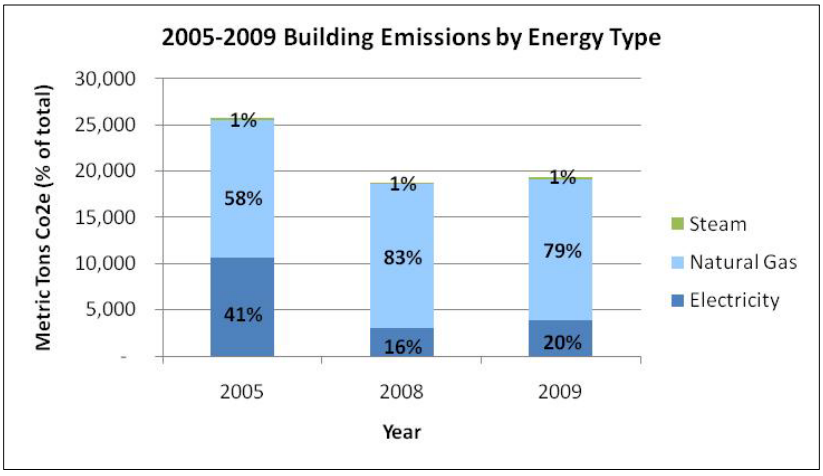

Figure 3 2005-2009 Building Energy Emissions by Energy Type

[2] SCL electricity is not included in total emissions because these emissions are accounted for in the electric utility sector. SCL purchases offsets for these emissions, effectively zeroing out these emissions.

2.1 Building Emissions by Department Ownership

The following tables and charts show 1990 to 2009 energy consumption from steam, natural gas and electricity consumption by City Department.

2.1a Electricity Consumption and Emissions

Table 5 1990 - 2009 Electricity Consumption

	Electricity Consumption, MWH					Electricity Emissions, MgCo2e				
Department	1990	2005	2008	2009	% change 2005-2009	1990	2005	2008	2009	% change 2005-2009
FAS	n.d.	52,020	53,420	60,250	16%	n.d.	1,350	700	860	-36%
Fire	n.d.	4,320	6,290	5,420	25%	n.d.	240	80	80	-67%
Library	n.d.	8,600	10,630	9,460	10%	n.d.	240	140	130	-46%
Parks	n.d.	22,890	15,340	23,910	4%	n.d.	640	200	340	-47%
Neigborhoods	n.d.	130	-	-	-	n.d.	4	-	-	-
SC	n.d.	12,250	34,480	15,780	29%	n.d.	340	220	220	-35%
SCL	n.d.	n.d.	17,020	33,660	-	n.d.	n.d.	450	480	-
SDOT	n.d.	3,020	4,140	6,110	102%	n.d.	80	50	90	13%
SPU	n.d.	24,360	27,340	28,150	16%	n.d.	4,610	1,350	1,650	-64%
Unknown accts	n.d.	330	n.d.	n.d.	-	n.d.	10	n.d.	n.d.	-
Total	n.d.	127,600	168,660	182,750	43%	n.d.	7,520	3,210	3,850	-49%

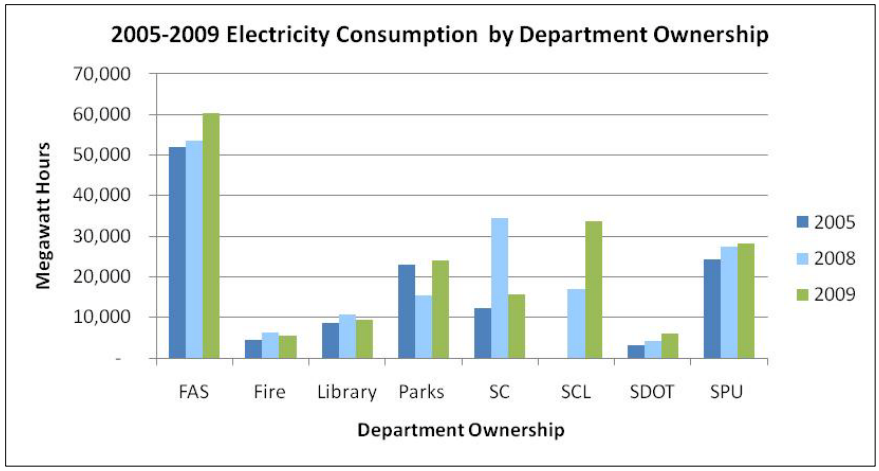

Figure 4 2005-2009 Electricity Consumption by Department Ownership

2.1b Natural gas consumption

Table 6 1990-2009 Natural Gas Consumption and Emissions

	Natural Gas Consumption, Therms						Natural Gas Emissions, MgCo2e					
Department	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009
FAS	578,310	771,130	619,710	619,710	7%	-20%	3,560	4,070	3,300	4,170	17%	2%
Fire	132,730	169,930	230,560	230,560	74%	-	810	900	1,230	1,050	30%	17%
Library	85,320	92,930	99,280	99,280	16%	7%	500	490	530	520	4%	6%
Parks	1,554,790	1,120,740	1,285,400	1,223,440	-21%	9%	9,500	5,910	6,840	6,510	-31%	10%
SC	654,150	489,750	563,300	455,040	-30%	-7%	3,980	270	3,000	2,420	-39%	796%
SCL	n.d.	n.d.	54,410	35,780	-	-	n.d.	2,580	290	190	-	-93%
SDOT	n.d.	n.d.	8,380	7,630	-	-	n.d.	n.d.	40	40	-	-
SPU	417,140	93,350	64,420	157,790	-62%	69%	2,530	490	230	410	-84%	-16%
Unknown accts	n.d.	34,210	n.d.	n.d.	-	-	n.d.	180	n.d.	n.d.	-	-
Total	3,422,440	2,772,050	2,925,450	2,829,220	-17%	2%	20,880	14,890	15,450	15,310	-27%	3%

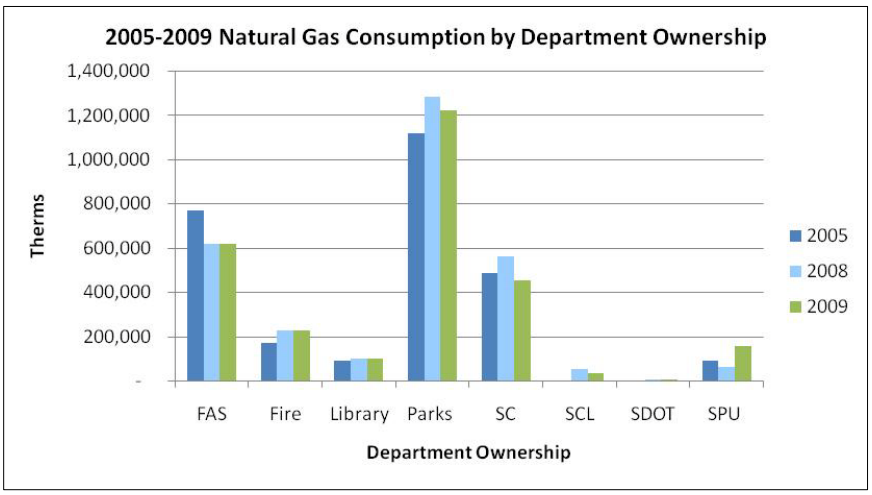

Figure 5 2005-2009 Natural Gas Consumption by Department Ownership

2.1c Steam Consumption and Emissions

Since 1990, the City of Seattle has owned four buildings that receive steam energy: the Arctic Building, the Dexter-Horton Building, Fire Station Headquarters, and the Central Library. In May of 2005, the City sold the Arctic Building so the emissions in Table 7 represent only those occurring prior to sale. The Dexter-Horton Building was sold in 2000 so only the contributed to 1990 steam emissions.

Table 7 1990-2009 Steam Consumption and Emissions

	Steam Consumption, MLBs					Steam Emissions, MgCo2e					
Department	1990	2005	2008	2009	% change 2005-2009	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009
FAS (Artic Building)	n.d.	690	-	-	-	n.d.	65	-	-	-	-
FAS (Dexter-Horton Building)	n.d.	-	-	-	-	n.d.	-	-	-	-	-
Fire (Headquarters)	n.d.	750	950	850	13%	n.d.	70	80	80	-	14%
Library (Central Library)	n.d.	450	820	630	40%	n.d.	40	70	60	-	50%
Total	n.d.	1,890	1,770	1,480	-22%	740	170	160	130	-82%	-24%

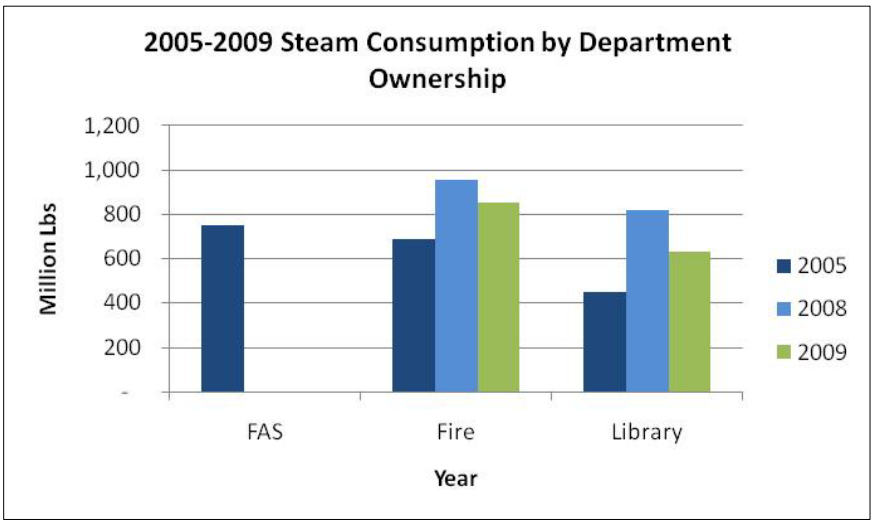

Figure 6 2005-2009 Steam Consumption by Department Ownership

3 – Vehicle Fleet

The City of Seattle operates a vehicle fleet with approximately 4,100 vehicles. About half the fleet consists of light duty passenger cars, light trucks and vans, while the other half are heavy-duty vehicles. Close to 600 of the light duty vehicles are gasoline electric hybrids. The operation of vehicles contributes to greenhouse gas emissions in two major ways. Vehicles burn gasoline, diesel, and other fuels, which results in greenhouse gas emissions. In addition, vehicles with air conditioning or refrigeration equipment emit hydrofluorocarbons (HFCs) and other greenhouse gases when these systems leak.

The City of Seattle vehicle fleet is a source of Scope 1 emissions from the combustion of mobile fuels, and to lesser extent refrigerants that leak from vehicle air conditioning systems. The following table and figures show amount of fuel consumed and emissions generated from City-owned vehicle fleets.

As can be seen in the table below, fuel consumption in 2009 was actually lower than in 2008 – 2,503,100 compared to 2,530,760. However, due to declines in the use of B20 and B40 biodiesel, emissions rose by just over 1,400 metric tons CO_2e. The biogenic portion of the biodiesel is excluded because the carbon concerned is of biogenic origin and would have been emitted to the atmosphere through the natural process of decay. The decline in gasoline consumption between 2008 and 2009 – over 60,000 gallons – can be attributed to increased use of high-efficiency hybrid passenger vehicles, as well as efforts across City departments to carpool, to reduce unnecessary trips, and to use the most efficient vehicle possible.

Table 8 Vehicle Fleet Emissions by Source

	Fuel Consumption, Gallons						Emissions by Fuel Type, MgCo2e					
	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009
Gasoline	1,403,890	1,386,720	1,443,180	1,382,790	-2%	-0.3%	12,360	12,160	12,670	12,140	-2%	-0.2%
Diesel	603,870	294,150	200,650	735,750	22%	150%	6,060	2,950	2,050	7,510	24%	155%
Biodiesel (B20)	-	523,880	243,680	22,590	-	-96%	-	4,210	1,990	180	-	-96%
Biodiesel (B40)	-	-	635,410	357,900	-	-	-	-	3,890	2,190	-	-
CNG	32,470	17,580	7,840	4,080	-87%	-77%	220	120	50	30	-86%	-75%
LPG	14,130	7,780	-	-	-	-	80	40	-	-	-	-
Other vehicles	n.d.	n.d.	-	-	-	-	3,500	2,280	-	-	-	-
Totals	2,054,360	2,230,110	2,530,760	2,503,110	22%	12%	22,220	21,760	20,650	22,050	-1%	1%

Table 9 Vehicle Refrigerant Usage

	Refrigerant Consumed (pounds)				Emissions (MgCo2e)			
	1990	2005	2008	2009	1990	2005	2008	2009
Refrigerants	n.d.	n.d.	240	240	n.d.	n.d.	140	140

The following chart shows change in carbon dioxide emissions by fuel source from City-owned vehicles from 1990 to 2009.

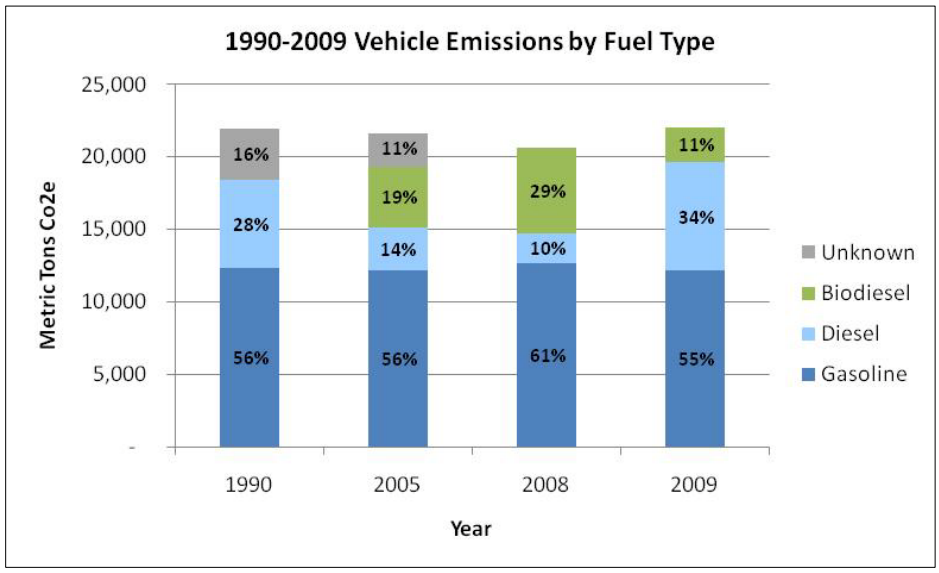

Figure 7 2005-2009 Vehicle Emissions by Fuel Type

The Police Department consumed the most fuel of any department in 2008 and 2009, followed by SPU (Figure 8). The following departments have vehicle fleet emissions that total less than 100 metric tons carbon dioxide equivalent, or less than 5,000 gallons of fuel consumed, and are not included in Figure 8: Arts & Culture Human Services, Information Technology, Housing, Law, Mayor's Office, Municipal Court, Neighborhoods, and Seattle City Light.

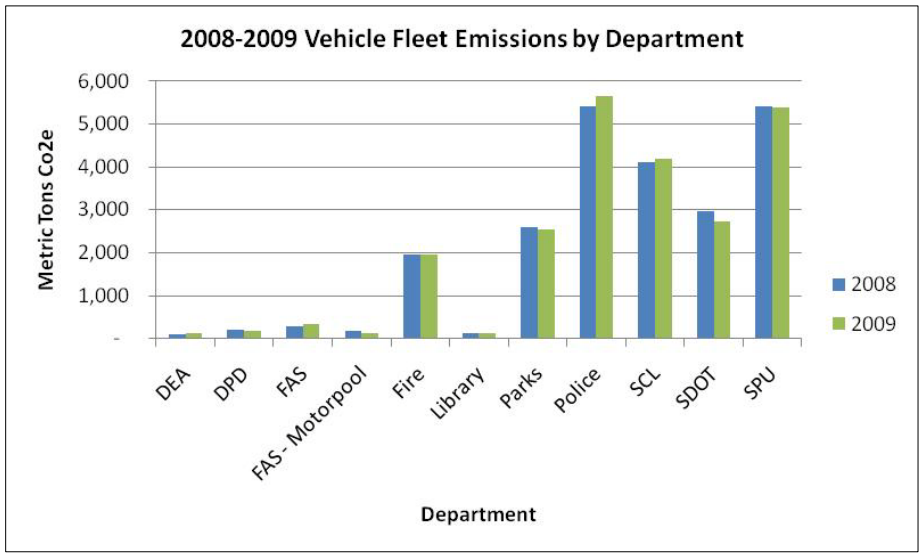

Figure 8 2008-2009 Vehicle Fleet Emissions by Department

The following chart shows that Seattle Public Utilities has the highest per employee emissions from fuel consumption, followed by SDOT, Police, and the Parks department (Figure 9). Figure 9 includes only departments with employee emissions greater than .3 metric tons.

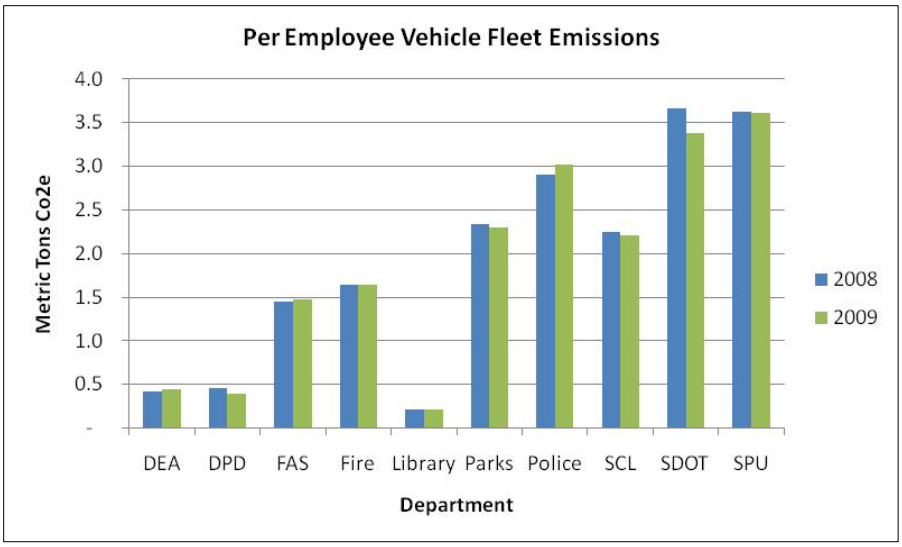

Figure 9 2008-2009 Vehicle Emissions per Employee by Department

4 – Solid Waste

4.1 Solid Waste Landfills

Emissions from the Solid Waste Landfills sector are the result of waste deposited in closed City of Seattle landfills. They are Scope 1 emissions. There are six closed landfills that the City operates: Interbay, Genessee, Judkins Park, South Park, Kent Highlands, and Midway. Of these landfills, Kent-Highlands and Midway have systems that fully cap and flare methane, and Interbay has a partial monitoring system. For the unmonitored landfills – Genessee, Judkins Park, and South Park – emissions are estimated based on a per-volume emissions rate assumed to be equal to that of Interbay. The scale of these emissions depends upon the size and type of the landfill and the presence of a landfill gas collection system.

After being placed in a landfill, organic waste (such as paper, food scraps, and yard trimmings) is initially decomposed by aerobic bacteria. After the oxygen has been depleted, the remaining waste is available for consumption by anaerobic bacteria, which break down organic matter into substances such as cellulose, amino acids, and sugars. These substances are further broken down through fermentation into gases and organic compounds that form the substrates for the growth of methanogenic bacteria. These CH4-producing anaerobic bacteria convert the fermentation products into stabilized organic materials and biogas consisting of approximately 50 percent CO2 and 50 percent CH4, by volume.

Once a landfill is closed and is no longer accepting material, methane emissions gradually decline over time as the organic matter they contain decays. This trend can be seen with the decline in emissions from 1990 to 2009. The emissions estimates shown here are based on the latest EPA methods found in the Mandatory Reporting Rule, estimating methane capture for capped landfills at 95%.

Table 10 Landfill Emissions by Source

	Emissions, $MgCO_2e$					
Landfill	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009
Interbay	68,000	31,600	27,900	18,700	-73%	-41%
Genessee	64,600	30,100	26,500	17,700	-73%	-41%
Judkins Park	11,600	5,400	2,800	1,900	-84%	-65%
South Park	13,600	6,300	4,700	3,200	-76%	-49%
Kent-Highlands	192,900	n.d.	2,700	2,400	-99%	-
Midway	n.d.	n.d.	600	500	-	-
Totals	350,600	73,400	65,300	44,300	-87%	-40%

4.2 Government Generated Solid Waste

Emissions reported in the Government Generated Solid Waste sector are an estimate of waste produced by City of Seattle employees at work. They are a Scope 3 source.

Typical sources of waste in local government operations include paper and food waste from offices and facilities, construction waste, and plant debris. Organic materials in government-generated solid waste (including paper, food scraps, plant debris, textiles, wood waste, etc.) generate methane as they decay in the anaerobic environment of a landfill. Also included here are estimates of emissions associated with other aspects of solid waste management, including the collection and processing of waste and recyclable materials.

Table 11 Government Generated Solid Waste Emissions by Source

		Emissions, $MgCO_2e$			
	Type	1990	2005	2008	2009
Recycling & Composting	Collection	n.d.	n.d.	120	110
Recycling & Composting	Processing	n.d.	n.d.	510	420
Disposal	Collection	n.d.	n.d.	170	150
Disposal	Transfer and Long Haul	n.d.	n.d.	450	400
Disposal	Landfill Emissions Commitment	n.d.	n.d.	2,200	2,000
Totals		n.d.	n.d.	3,450	3,080

Solid waste disposal in the City of Seattle is contracted to a third-party supplier. This contractor services the entire city, including City of Seattle facilities. The numbers shown above are an estimate based on the City's percentage share of total citywide employment. They show an 11% decline in emissions from government-generated solid waste. While it is likely that City of Seattle emissions did decline, these figures are most likely driven by citywide economic trends and the aggregate impact of citywide efforts to reduce waste and boost recycling rates more so than operating policies at City of Seattle facilities.

4.3 Avoided Emissions from Recycling and Landfill Carbon Stored

4.3a Landfill Carbon Stored

The majority of government generated solid waste 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. This remaining portion represents carbon sequestration, 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 product. The values are calculated for the waste disposed of in the listed calendar year, but represent the sequestration enduring only after that waste's decay is complete, many years in the future. In 2008, carbon sequestration in landfills from government-generated solid waste was 3,300 metric tons of CO_2e. In 2009, it was 3,200 metric tons.

Table 12 Landfill Carbon Stored

	Emissions, $MgCO_2e$			
Type	**1990**	**2005**	**2008**	**2009**
Landfill Carbon Stored	n.d.	n.d.	(3,300)	(3,200)

4.3b Recycling

By recycling large amounts of material, Seattle Public Utilities' recycling program avoids emissions associated with disposal of municipal solid waste, as well as the manufacture of new materials and products. The benefit of avoided materials manufacture far surpasses emissions from collecting and processing recyclable material. In 2008, the government operations share of avoided emissions from collection and disposal was 3,200 metric tons CO_2e. Avoided manufacturing emissions were 14,100 metric tons. In 2009, the figures were 2,900 and 12,000 metric tons CO_2e, respectively.

Table 13 Avoided Emissions from Recycling

	Emissions, $MgCO_2e$			
Type	**1990**	**2005**	**2008**	**2009**
Avoided landfill emissions from recycling	n.d.	n.d.	(3,200)	(2,900)
Avoided emissions from manufacture of new materials and products	n.d.	n.d.	(14,100)	(12,000)
Total	n.d.	n.d.	(15,292)	(12,891)

Avoided emissions from recycling and carbon stored from landfill waste far exceed the emissions generated from waste collection, transport to the landfill, and the methane released from decaying waste. Figure 10 shows the emissions produced and avoided from municipal solid waste.

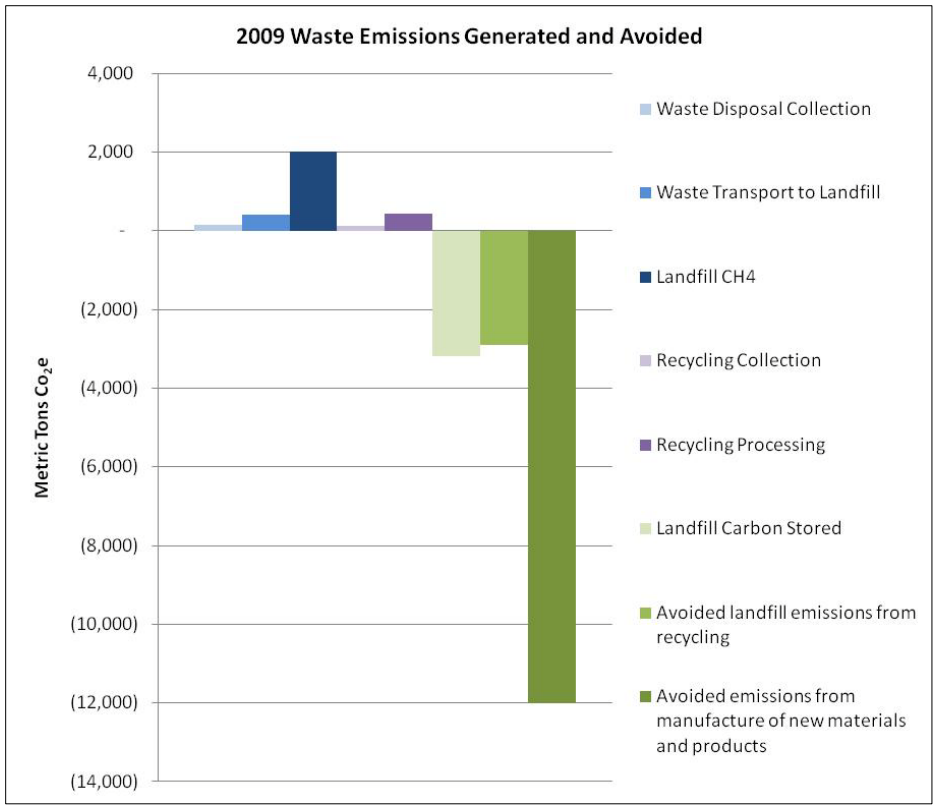

Figure 10 2009 Waste Emissions Generated and Avoided

5 – Street Lights and Traffic Signals

City of Seattle street lights and traffic signals are a source of Scope 2 emissions from electricity consumption. The City has approximately 82,000 street lights. The energy consumption and emissions from this sector also include traffic signals and other traffic control signs such as pedestrian crossing signals.

Table 14 Street Light and Traffic Signal Emissions by Source

	Electricity consumed, KWh				Emissions, $MgCO_2e$			
	1990	2005	2008	2009	1990	2005	2008	2009
Street Lighting	n.d.	79,300,000	79,083,500	79,083,500	n.d.	2,200	1,000	1,100
Pedestrian Lighting	n.d.	-	196,800	196,800	n.d.	-	3	3
Traffic Control	n.d.	3,560,000	2,945,000	2,945,000	n.d.	100	40	40
Totals	n.d.	82,860,000	82,225,000	82,225,000	n.d.	2,300	1,100	1,200

As shown in the table above, the energy consumption for Seattle's Street Lights and Traffic Signals was the same in 2008 and 2009. Consumption in 2005 was only slightly higher. The City is in the midst of a major lighting replacement initiative in which 40,000 streetlights with energy-efficient LED technology will be installed during the next 5 years. This will result in a significant decline in emissions from lighting.

As it stands now, emissions increased slightly from 2008 to 2009 due to a small change in the electricity emissions factor between those years, due to changes in the carbon content of electricity purchased by City Light.

6 – Employee Commute

Emissions from the Employee Commute sector result from the combustion of mobile fuels in personal vehicles and vanpool vehicles from travel to and from work. These are Scope 3 emissions.

Table 15 Employee Commute Emissions by Commute Mode

	Fuel Consumed, gallons				Emissions, $MgCO_2e$			
Commute Mode	**1990**	**2005**	**2008***	**2009**	**1990**	**2005**	**2008***	**2009**
Drive Alone	n.d.	813,390	781,350	733,680	n.d.	7,140	6,860	6,440
Carpool	n.d.	226,840	81,930	139,340	n.d.	1,990	720	1,220
Vanpool	n.d.	4,440	990	3,770	n.d.	40	10	30
Total	n.d.	1,044,670	864,270	876,790	n.d.	9,170	7,590	7,690

* Based on 2007 Commute Trip Reduction Survey results

As the table above shows, commute emissions have decreased by 16% since 2005. The employee commute data is from a survey conducted by King County Metro biannually, as part of Washington's Commute Trip Reduction program, and includes only sites with over 100 employees. The Commute Trip Reduction Program requires biannual reporting of commute trips for all facilities with over 100 employees. The 2009 survey had a 67% response rate, whereas the 2008 survey response rate was only 26%. Therefore, the 2009 results should be considered the most accurate depiction of emissions from employee commutes.

The per-employee emissions by work site show that since 2005, emissions have steadily decreased at the Central Building Downtown (CBD), Haller Lake, Seattle Center, and Parks' facility on Marginal Way (Figure 11). Emissions at the Charles Street Complex and City Light's North and South Service centers have increased since 2005, and emissions from the Utility Field Operations commute trips have stayed roughly the same since 2005. The lower commute emissions values for CDB and Utility Field Operations in 2008 could be due to the small sample size of the 2008 survey.

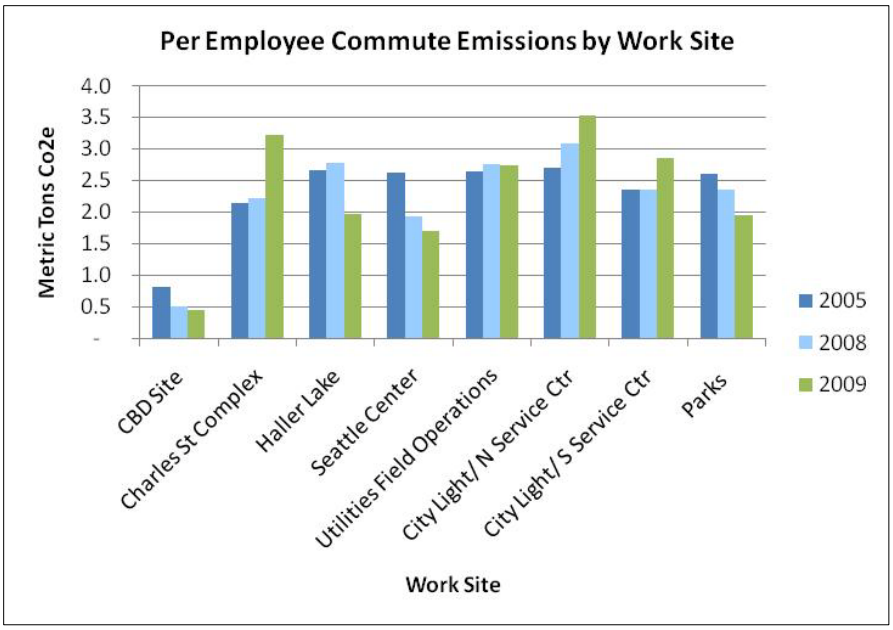

Figure 11 2005- 2009 per Employee Commute Emissions by Work Site

7 – Employee Air Travel

City of Seattle employees travel by air to attend meetings, conferences, and trainings. The passenger miles traveled by City employees and the emissions associated with this travel are shown below. The passenger miles traveled includes flights purchased by the City and by outside agencies or organizations. Emissions from the Employee Air Travel sector result from the combustion of mobile fuels in commercial aircraft. These are Scope 3 emissions. From 2005 to 2009, air travel emissions decreased by 8%, likely due to the recession and to a decrease in departments' travel budget. Most of the air travel data is based on trips recorded by City employees through the travel authorization form. Since the travel authorization form is only required for air travel purchased by the City, and employees frequently take trips paid for by outside organizations and agencies, the air travel data likely under represents total air miles traveled at the City.

Table 16 Employee Air Travel Emissions by Flight Distance

	Distance Traveled (Passenger Miles)				Emissions (Metric Tons Co2e)					
Flight Distance	1990	2005	2008	2009	1990	2005	2008	2009	% change 1990-2009	% change 2005-2009
Short	n.d.	n.d.	21,300	13,800	n.d.	n.d.	20	10	-	-
Medium	n.d.	n.d.	155,800	127,900	n.d.	n.d.	100	110	-	-
Long	n.d.	n.d.	5,245,300	4,425,000	n.d.	n.d.	2,700	2,030	-	-
Total	n.d.	4,536,140	5,422,460	4,634,240	5,060	2,330	2,810	2,150	-58%	-8%

The table and figure below show total emissions by department for 2008 and 2009 (Table 17, Figure 12). There is no data on department-specific travel for 1990 or 2005. Staff from City Light flew the greatest number of miles in 2008 and the staff from the Police Department flew the greatest number of miles in 2009. The Police department has high passenger miles traveled due to required trainings.

Table 17 Employee Air Travel Emissions by Department

	Distance Traveled (Passenger Miles)				Emissions (Metric Tons Co2e)			
	1990	2005	2008	2009	1990	2005	2008	2009
Arts	n.d.	n.d.	n.d.	12,720	n.d.	n.d.	n.d.	10
Civl Rights	n.d.	n.d.	110,000	46,820	n.d.	n.d.	60	20
DEA	n.d.	n.d.	127,930	25,660	n.d.	n.d.	70	10
DoIT	n.d.	n.d.	n.d.	186,680	n.d.	n.d.	n.d.	100
DON	n.d.	n.d.	72,020	65,610	n.d.	n.d.	40	10
DPD	n.d.	n.d.	232,740	175,610	n.d.	n.d.	120	90
FFD	n.d.	n.d.	n.d.	205,210	n.d.	n.d.	n.d.	110
Fire	n.d.	n.d.	162,710	469,090	n.d.	n.d.	80	240
Housing	n.d.	n.d.	44,650	66,740	n.d.	n.d.	20	30
HSD	n.d.	n.d.	150,780	179,090	n.d.	n.d.	80	90
Law	n.d.	n.d.	49,560	44,990	n.d.	n.d.	30	20
Legis	n.d.	n.d.	242,330	222,060	n.d.	n.d.	120	110
Library	n.d.	n.d.	239,610	234,170	n.d.	n.d.	120	120
Mayor's Office	n.d.	n.d.	47,970	73,510	n.d.	n.d.	20	40
OED	n.d.	n.d.	n.d.	45,610	n.d.	n.d.	n.d.	20
OIR	n.d.	n.d.	56,010	25,310	n.d.	n.d.	30	10
OPM	n.d.	n.d.	30,220	4,640	n.d.	n.d.	20	-
OSE	n.d.	n.d.	38,240	53,940	n.d.	n.d.	20	30
Parks	n.d.	n.d.	213,050	126,030	n.d.	n.d.	120	70
Personnel	n.d.	n.d.	54,520	16,940	n.d.	n.d.	30	10
Police	n.d.	n.d.	1,241,050	1,188,400	n.d.	n.d.	640	610
Seattle Center	n.d.	n.d.	12,000	8,000	n.d.	n.d.	10	-
SCL	n.d.	n.d.	1,468,820	710,410	n.d.	n.d.	750	360
SDOT	n.d.	n.d.	173,850	261,890	n.d.	n.d.	90	140
SPU	n.d.	n.d.	668,150	193,110	n.d.	n.d.	350	100
Total	**n.d.**	**4,536,140**	**5,422,460**	**4,634,240**	**n.d.**	**2,330**	**2,800**	**2,360**

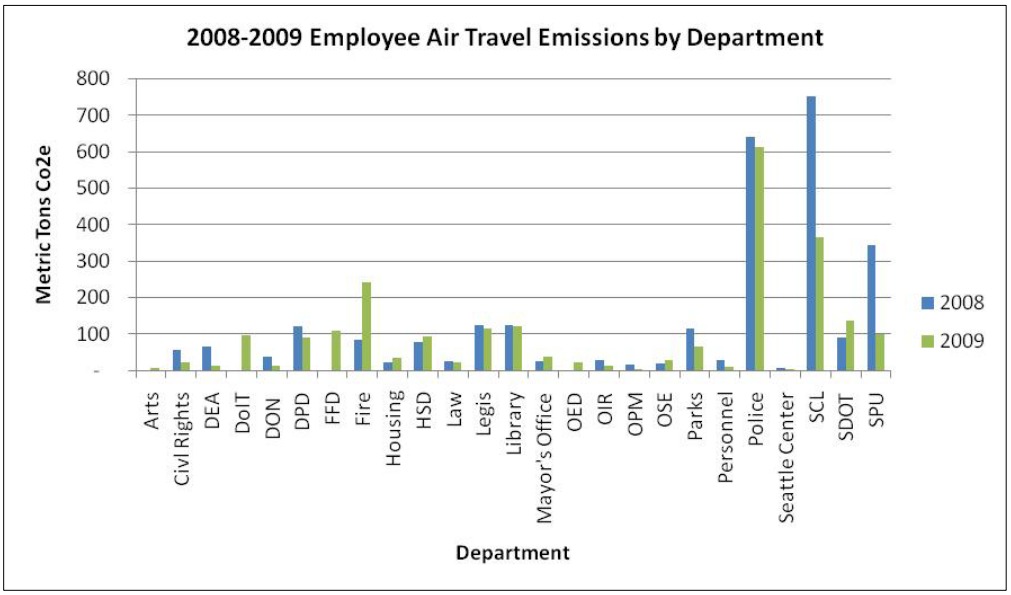

Figure 12 2008-2009 Air Travel Emissions by Department

As shown in Figure 13, in 2009, Office of Sustainability & Environment (OSE) had the highest per employee air travel, followed by the Mayor's Office. OSE has only seven full-time staff, and the majority of staff members attend conferences and meetings that require air travel as part of their work plan, leading to high number of per-employee emissions. Departments with per employee emissions of less than .2 metric tons are not included in the chart, and include Law, Policy & Management, Neighborhoods, Personnel, SPU, Parks, and Executive Administration. For the number of employees per department, see Appendix A.

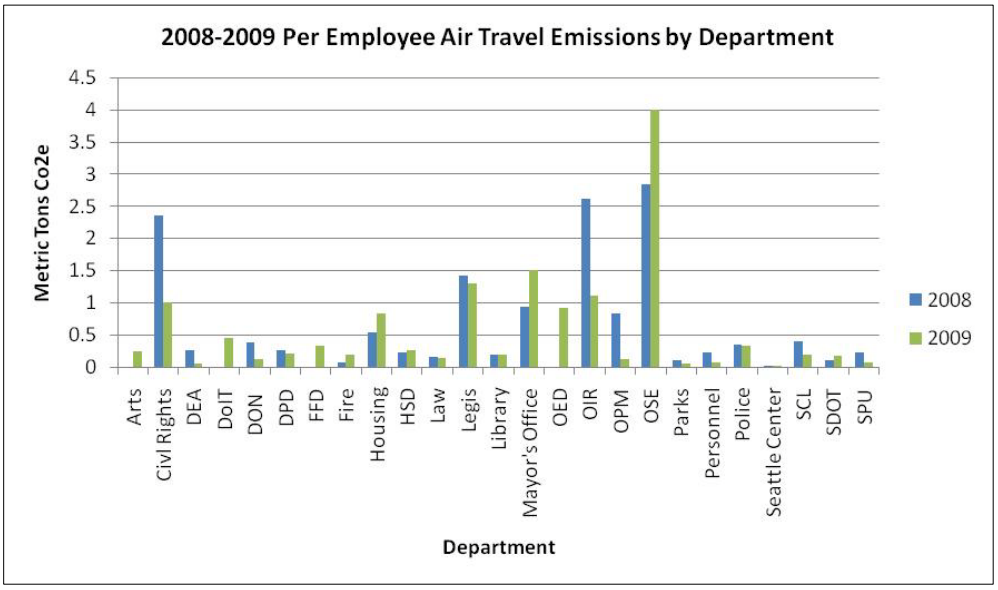

Figure 13 2008-2009 per Employee Air Travel Emissions by Department

8–Electric Utility Offsets

Over 90% of Seattle City Light's owned or purchased electricity generation is from hydro and wind power, but there are some emissions associated with market purchases. Since 2005, City Light has invested in carbon reduction projects to offset the emissions associated with its electricity purchases. City Light purchases offsets that meet the standards of the Climate Action Reserve or the Voluntary Carbon Standard. Most offsets come from agricultural and landfill methane capture projects. City Light seeks projects that are local, verifiable, reasonably priced, 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. In 2008, City Light purchased offsets totaling 64,300 metric tons CO_2e. In 2009, 17,100 metric tons of offsets were purchased.

Table 18 Seattle City Light Purchased Offsets

	Emissions, $MgCO_2e$			
Sector	**1990**	**2005**	**2008**	**2009**
Seattle City Light Purchased Offsets	n.d.	n.d.	64,300	17,100

Conclusion

Overall, since 2005, City of Seattle emissions from operations decreased by nearly 50%, due to the large decrease in emissions from City Light energy generation. Although City Light purchases offsets for these emissions, efforts to conserve electricity reduces the amount of electricity that City Light has to purchase to supplement hydropower, thus reducing the carbon content of regional electricity use.

Emissions decreased in all other sectors except for vehicle fleet emissions, which increased slightly. Specifically, building emissions have decreased by 10%, vehicle emissions have increased by 1%, and emissions from closed landfills decreased by 40% between 2005 and 2009. Of the emissions generated from City operations, vehicle fleet fuel use and building energy use are the two largest sources (35% and 31% respectively). At 24%, employee commutes also generate a substantial share of the City's emissions. The results of the inventory show that transportation and building energy use are the two greatest sources of emissions from City operations, which mirror the largest sources of emissions produced by the greater Seattle community.

The City of Seattle is working to develop a Corporate Climate Action Plan with reduction targets and actions for each sector, including waste, energy use, vehicle fuel use, commuting, air travel, and product purchasing. For more information on the City of Seattle's Climate Protection Initiative, visit http://www.seattle.gov/environment/climate.htm.

Appendix A - Employee Count by Department

Table 19 Employee Totals per Department

Department	2008	2009
Arts & Cultural Affairs	27	27
City Finance Office	40	37
City Light	1,831	1,891
Dept of Planning & Development	448	441
Dept of Executive Admin	254	253
Fire Department	1,189	1,185
Fleets & Facilities	319	319
Housing	43	42
Human Services	336	349
Information Technology Dept	217	216
Intergovernmental Relations	11	12
Law Department	164	162
Legislative-City Council	88	88
Library	626	626
Mayor's Office	26	25
Municipal Court	246	247
Neighborhoods Dept	97	95
Office for Civil Rights	24	24
Office of Economic Development	26	26
Office of Policy & Management	19	18
Office of Sustainability & Env	7	7
Parks Dept	1,109	1,100
Personnel Dept	124	125
Police Dept	1,868	1,875
Seattle Center	296	289
SDOT	807	807
Seattle Public Utilities	1,495	1,495

Appendix B - Methodology

Introduction

This document specifies the emissions sources, methodologies and data sources used to calculate the emissions for each of the sectors included in the City of Seattle's 2008 and 2009 Corporate Greenhouse Gas Emissions Inventories. These sectors are: buildings and facilities, vehicle fleets, street lights and traffic signals, government generated solid waste, municipal power generation, employee commute, and employee air travel.

Methodology organization:

For each sector, the report includes information about the emission source and scope, calculation steps, protocol used, emissions factors, and data sources, including references to source files and relevant Master Data Workbook (MDW) tabs. This document will make frequent reference to the Local Government Operations,[3] as well as to worksheets contained in the City of Seattle's 2008 and 2009 Master Data Workbooks (MDW). The reader should have available and be familiar with both of these resources to fully take advantage of the information provided below.

Data files:

Data sources are listed according to their reference number. Each file used in the inventory is numbered and listed in the 'data log' tab of the Master Data Workbook (MDW). All files used in the inventory are numbered according to a six-digit numbering system: xx (year)- xx (category)- xx (file number + name of file). Unless otherwise noted, the emissions sources and methodologies for each year are the same.

Master Data Workbooks:

The Master Data Workbooks are a means for compiling all the pieces of information that feed into the inventory. There is a MDW for each inventory year. Each inventory sector has several tabs in the MDW, including the following.

- Raw Data – this is information that is copied directly from the source spreadsheets. It is unformatted, and serves as a way to aggregate multiple source documents into one location.

- Working Data – this is information that is copied from the raw data tabs and formatted into a cleaner, easier to read format.

- Final Data – Final data are sector totals of activity data, usually energy consumption or material consumption. This information is drawn from the working data tabs. Final data also includes emissions calculations.

Emissions calculations are made using the totaled figures entered on the final data tabs.
Each MDW worksheet contains a brief explanation of the contents of the worksheet, the origin of the content, and notes on changes that were made to the information.

[3] The Local Government Operations Protocol can be downloaded from the following web site: http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/

Inventory Organization:

The City of Seattle inventory divides emissions into categories based on level of control, as specified by the LGO Protocol. The categories, or scopes, allow the inventory to separately account for direct and indirect emissions and improve transparency. The scope definitions in the LGO Protocol follow the WRI/WBCSD GHG Protocol Corporate Standard, and include the following.

Scope 1: All direct GHG emissions (with the exception of direct CO2 emissions from biogenic sources). For Seattle's inventory, this includes equipment and materials owned by the City government, such as on-site natural gas heating and vehicle fleets.

Scope 2: Indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. Scope 2 emissions include wholesale energy imports into the city-owned electric system, as well as retail energy purchased by other city-owned facilities.

Scope 3: All other indirect emissions not covered in Scope 2, such as emissions resulting from the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity (e.g., employee commuting and business travel), outsourced activities, waste disposal, etc.

Together the three scopes provide a comprehensive accounting framework for managing and reducing direct and indirect emissions. The LGO Protocol provides standard methodologies for calculating emissions from the sources shown in the table below.

Table 20 Inventoried Emissions Sources by Scope

Scope 1	Scope 2	Scope 3
Fuel consumed to heat/cool facilities	Purchased electricity consumed by facilities	Solid waste generated by government operations
Fuel consumed by vehicle fleet and mobile equipment	Purchased steam for heating or cooling facilities. Purchased electricity consumed by electric vehicles	Fuel consumed for employee vehicles used for commuting
Fuel consumed to generate electricity	Purchased steam for heating or cooling facilities	Fuel consumed for airplanes used for employee business travel
Electricity, steam, and cooling purchased from an outside utility		
Leaked refrigerants from facilities and vehicles		
Solid waste in government landfills		

While LGO Protocol standardizes inventories from government operations, it does not seek to be a wholly accurate inventory of all emissions sources, as certain sources are currently excluded or otherwise impossible to accurately estimate. This and all emissions inventories represent a best estimate of emissions using best available data and calculation methodologies; it does not provide a

complete picture of all emissions resulting from the City's operations, and emissions estimates are subject to change as better data and calculation methodologies become available in the future.

Types of Emissions:

As described in the LGO Protocol, emissions from each of the greenhouse gases can come in a number of forms:

Stationary or mobile combustion: These are emissions resulting from on-site combustion of fuels (natural gas, diesel, gasoline, etc.) to generate heat, electricity, or to power vehicles and mobile equipment.

Purchased electricity: These are emissions produced by the generation of power from utilities outside of the jurisdiction.

Fugitive emissions: Emissions that result from the unintentional release of greenhouse gases into the atmosphere (e.g., leaked refrigerants, methane from waste decomposition, etc.).

Process emissions: Emissions from physical or chemical processing of a material (e.g., wastewater treatment).

1 – Buildings and Facilities

Emission Sources

City of Seattle buildings are a source of Scope 2 emissions from electricity consumption and steam consumption. They are also a source of Scope 1 emissions from the direct combustion of natural gas as well as leaked refrigerants.

Methodology

1. Electricity Consumption

The quantification of emissions from **electricity consumption** follows the recommended methodology outlined in section **6.2.1 of LGO Protocol v1.1**.

The three main steps are:

1. Determine your annual electricity use from each facility;
2. Select the appropriate emission factors that apply to the electricity used; and
3. Determine your total annual emissions in metric tons of carbon dioxide equivalent.

Various departments provided annual electricity use totals for City of Seattle Buildings. The departmental totals were multiplied by the 2008 and 2009 Seattle City Light emission factor (28.99 and 31.35 lbs/ MWh CO2e, respectively) to determine annual emissions in metric tons of carbon dioxide equivalent.

2. Natural Gas Consumption

The quantification of emissions from **natural gas consumption** follows the recommended methodology outlined in section **6.1.1 of LGO Protocol v1.1**. Calculating emissions from stationary combustion using fuel use activity data involves four steps:

1. Determine annual consumption of each fuel combusted at your facilities;
2. Calculate each fuel's CO2 emissions;
3. Calculate each fuel's CH4 and N2O emissions; and
4. Convert CH4 and N2O emissions to CO2 equivalent and determine total emissions.

Various departments provided annual natural gas use totals for City of Seattle Buildings. Departmental totals were multiplied by the pipeline national average natural gas emission factor of 53.02 kg CO2/MMBtu from table G.1 of LGO Protocol v1.1 to determine annual emissions in metric tons of carbon dioxide equivalent.

3. Steam Consumption

The quantification of emissions from **steam consumption** follows the recommended methodology outlined in section **6.3 of LGO Protocol v1.1**. Some local governments purchase steam or district heating for purposes of providing space heating in the buildings – emissions associated with these sources are considered to be indirect. Section 6.3 provides guidance on calculating Scope 2 emissions from imported steam or district heating that is produced at a conventional boiler plant. There are four steps to estimate GHG emissions from imported steam or district heating:

1. Determine energy obtained from steam or district heating;
2. Determine appropriate emission factors for the steam or district heating;
3. Calculate emissions from imported steam or district heating; and
4. Convert to units of carbon dioxide equivalent, and determine total emissions.

Seattle Steam provided steam consumption in million pounds. Seattle Steam calculated emissions based on the carbon content of their fuel mix. There are three City of Seattle facilities that use steam – the aquarium, the main branch of the public library, and the main fire station.

4. Refrigerant leakage
The quantification of emissions from **refrigerant leakage** follows the alternate methodology outlined in section **6.6.2.1 of LGO Protocol v1.1** – the Simplified Mass Balance Method. Calculating HFC emissions using the simplified mass balance approach involves following these three steps:

1. Determine the types and quantities of HFC used at each facility;
2. Calculate annual emissions of each type of HFC; and
3. Convert to units of carbon dioxide equivalent and determine total HFC emissions at each facility.

Using data provided by FAS, factors from table G.1 of LGO Protocol v1.1 were used to determine annual emissions in metric tons of carbon dioxide equivalent.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

For 2008 data, see MDW worksheets "08-10 Buildings Raw Data" "08-10 Buildings Working Data", and "08-10 Buildings Final Data".

For 2009 data, see MDW worksheets "09-10 Buildings Raw Data" "09-10 Buildings Working Data", and "09-10 Buildings Final Data".

Table 21 Building and Facilities Data Sources

Department	Source File Year	
	2008	2009
Seattle Center	08-11-7 Seattle Center 2008 Energy Use Report	09-11-24 Seattle Center 2009 Energy Use Report
City Light	08-50-1 City Light Inventory as of 10.29.09 08-50-2 City Light Energy Used in Operation	09-11-15 City Light Energy Used in Operation
Fire, FAS	08-11-4 FFD_Energy_Usage_2006-2009 08-13-5 Seattle Fire Dept and Library and Aquarium load	09-11-12 2008-2009 Library Energy Consumption 09-13-5 Seattle Fire Dept and Library and Aquarium load
Libraries	08-11-2 2008-2009 Library Energy Consumption 08-13-5 Seattle Fire Dept and Library and Aquarium load	09-11-13 2008-2009 Library Energy Consumption 09-13-5 Seattle Fire Dept and Library and Aquarium load
Parks and Recreation	08-11-5 Parks_2008 - 2009_Energy_Usage	09-11-22 Parks 2009ElectricUse 09-11-23 Parks 2009NaturalGasUse
SDOT	08-11-19 2008 Seattle DOT Accts	09-11-18 SDOT Natural gas from

	electricity	PSE 11-01-10 09-11-19 Seattle DOT Accts 2009
SPU	08-11-17 pse accounts- SDOT 2009	09-11-20 SPU 2009 Energy Consumption-PSE 09-11-21 SPU 2009 Energy Consumption-SCL

2- Vehicle Fleet

Emission Sources

The City of Seattle vehicle fleet is a source of Scope 1 emissions from the combustion of mobile fuels, and to lesser extent refrigerants that leak from vehicle air conditioning systems. Mobile combustion sources include both on-road and off-road vehicles such as automobiles, trucks, buses, and construction equipment.

Methodology

Emissions from mobile combustion can be estimated based on vehicle fuel use and miles traveled data. CO2 emissions, which account for the majority of emissions from mobile sources, are directly related to the quantity of fuel combusted and thus can be calculated using fuel consumption data. CH4 and N2O emissions depend more on the emission control technologies employed in the vehicle and distance traveled. Calculating emissions of CH4 and N2O requires data on vehicle characteristics (which takes into account emission control technologies) and vehicle miles traveled. Because of this distinction, CO2 is calculated separately from CH4 and N20.

The quantification of emissions resulting from **fuel consumption** from the City of Seattle's vehicle fleet follows the recommended methodology for fuel consumption outlined in **section 7.1.1.1 of LGO Protocol v1.1.**

Calculating CO2 emissions using this approach involves three steps:

1. Identify total annual fuel consumption by fuel type;
2. Determine the appropriate emission factor; and
3. Calculate total CO2 emissions.

FAS provided fuel consumption totals in gallons by department. The City of Seattle uses gasoline, diesel, B20 biodiesel, B40 biodiesel, and compressed natural gas to power its vehicle fleet. The totals for each fuel type category were multiplied by emission factors from Table G.11 of LGO Protocol v1.1 – Default CO2 Emission Factors for Transport Fuels – to determine annual emissions in metric tons of carbon dioxide. For biofuel blends, the biogenic portion of the fuel was calculated and is reported separately from the fossil fuel component.

The quantification of emissions from **refrigerant leakage** follows the alternate methodology outlined in section **6.6.2.1 of LGO Protocol v1.1** – the Simplified Mass Balance Method. To calculate HFC emissions using the simplified mass balance approach, follow these three steps:

1. Determine the types and quantities of HFC used at each facility;
2. Calculate annual emissions of each type of HFC; and
3. Convert to units of carbon dioxide equivalent and determine total HFC emissions at each facility.

Using data provided by FAS, factors from table G.1 of LGO Protocol v1.1 were used to determine annual emissions in metric tons of carbon dioxide equivalent.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

For 2008 data, see MDW worksheets "08-20 Fleet Detailed Final" "08-20 Fleet Summary Final", and "08-20 Fleet Raw Data".

For 2009 data, see MDW worksheets "09-20 Fleet Detailed Final" "09-20 Fleet Summary Final", and "09-20 Fleet Raw Data".

Table 22 Vehicle Fleet Data Sources

Source	Source File Year	
	2008	2009
FAS	08-20-2 Fuel Data Detailed	09-20-1 Fuel Data (12-09 report)
FAS	08-20-3 Vehicle refrigerants	09-20-2 Vehicle refrigerants

3- Street Lights and Traffic Signals

Emission Sources

City of Seattle street lights and traffic signals are a source of Scope 2 emissions from electricity consumption.

Methodologies

The quantification of emissions from the City of Seattle's streetlights and traffic signals follows the **alternate methodology** for street light electricity consumption outlined **in section 6.2.2.4 of LGO Protocol v1.1**. In almost all cases, metered electricity consumption records are not available for streetlights and traffic signals. In these cases, the most accurate alternate methodology for estimating activity data is based on installed wattage. Scope 2 emissions from lighting use are based on installed wattage, following the steps below:

1. Determine the number and wattage of all bulbs in the system;
2. Estimate the average annual daily operating hours for each group of lights; and
3. Estimate annual electricity consumption for each group of lights.

Monthly energy use totals in kilowatt hours were provided by Seattle City Light for street lighting, traffic signals, and pedestrian lighting. Monthly usage was multiplied by 12 to achieve annual totals. The totals for each category were multiplied by the 2008 and 2009 Seattle City Light emission factor (28.99 and 31.35 lbs/ MWh CO2e, respectively) to determine annual emissions in metric tons of carbon dioxide equivalent.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

See the 2008 MDW worksheets “08-30 Street Lights and Traffic Signals Raw Data” “08-30 Street Lights and Traffic Signals Working Data”, and “08-30 Street Lights and Traffic Signals Final Data”.

For 2009, the relevant worksheets are “09-30 Street Lights and Traffic Signals Raw Data” “09-30 Street Lights and Traffic Signals Working Data”, and “09-30 Street Lights and Traffic Signals Final Data”.

Table 23 Street Light and Traffic Signals Data Sources

Source	Source File Year	
	2008	2009
City Light	08-30-2 Monthly street light & signal consumption	09-30-2 Monthly street light & signal consumption

4- Government Generated Solid Waste

Emission Sources

Emissions reported in the Government Generated Solid Waste sector are an estimate of waste City of Seattle employee’s produce during the time they spend at work. They are a Scope 3 source.

The collection, processing and disposal of solid waste can encompass many different sources of GHG emissions. The overall results for this sector are calculated using the EPA Waste Reduction Model (WARM). WARM is designed to help solid waste planners and organizations track and voluntarily report greenhouse gas (GHG) emissions reductions from different waste management practices. It calculates emissions in metric tons of carbon equivalent (MTCE), metric tons of carbon dioxide equivalent (MTCO2E), and energy units (million BTU) across a wide range of material types commonly found in municipal solid waste (MSW). WARM recognizes 40 material types; and it assesses GHG benefits from a systems perspective to show how manufacturing, transportation, and end-of-life disposal practices relate to materials management. It is a life-cycle tool, and accounts for all emissions connected to the good or service regardless of which industrial or economic sectors produce these emissions and when these benefits occur over time. As such, the numbers produced by WARM are not reflective of emissions from the inventory year, but rather of emissions caused by materials consumed during the inventory year.

Methodology

Government Generated Solid Waste is a Scope 3 emissions source. As such, there is no methodology specified by the LGO Protocol, however, ICLEI has developed general guidance for its members on quantifying emissions from this source. The ability of each jurisdiction to adhere to that guidance is dependent on existing practices and availability of data.

The City of Seattle does maintain a thorough inventory of municipal solid waste generation and disposal, as well as statistics on solid waste generation and disposal amounts for various different occupation categories and facility types. As discussed above, the City of Seattle uses the EPA WARM method to estimate the emissions impact of its waste management practices.

The City’s share of total waste was based on the City’s share of citywide employment. The City has 10,998 employees. Citywide employment is 501,234, making the City’s share of total waste 2.2%. As such, for each category of recycling and waste disposal, government operations were assumed to contribute 2.2% of the citywide total.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

See the 2008 MDW worksheets "08-40 MSW Raw Data" "08-40 MSW Working Data", and "08-40 MSW Final Data". For 2009, the relevant worksheets are "09-40 MSW Raw Data" "09-40 MSW Working Data", and "09-40 MSW Final Data".

Table 24 Government Generated Solid Waste Data Sources

Source	Source File Year	
	2008	2009
Personnel	08-40-3 Employee count 11.2.10	09-40-3 Employee count 11.2.10
SPU	08-40-4 Waste Generation/Disposal	09-40-4 Waste Generation/Disposal

4.1- Solid Waste Landfills

Emission Sources

Emissions from the Solid Waste Landfills sector are the result of waste deposited in City of Seattle landfills. There are no active landfills within the City, but there are six closed landfills that the City operates – Interbay, Genessee, Judkins Park, South Park, Kent Highlands, and Midway – and is able to generate estimates of ongoing methane release. Of these landfills, Interbay, Kent-Highlands, and Midway are at least partially monitored for methane emissions.

While the collection, processing and disposal of solid waste can encompass many different sources of GHG emissions; this calculation focuses solely on estimating the fugitive CH4 emissions released by closed City of Seattle landfills.

Methodology

Calculation methods:

Interbay is partially monitored for methane emissions. Seattle Public Utilities has evaluated the Interbay, Genesee, Judkins Park and South Park landfills through historical and contemporary topographic information to estimate their volumes; hence emissions estimates for the unmonitored landfills can be estimated from volume ratios.

The following calculation methods were used to estimate the emissions from closed landfills within City limits:

1. Min-Soon Yim, SPU provided Interbay monitoring data with methane emissions from the portion of the landfill that is under vacuum.
2. Emissions for the entire landfill were estimated by multiplying the monitored value by 7.2, the ratio of total landfill surface area to surface area over the extraction system.
3. Ratios of other landfill volumes to Interbay's volume are provided by Jeff Neuner, SPU.
4. Emissions estimates for Genessee, Judkins Park and South Park are all generated by multiplying Interbay's emissions by the respective volume ratios

Midway & Kent Highlands Landfills

The LGO Protocol and the Environmental Protection Agency (EPA) both have methodologies in place for calculating GHG emissions from landfills. LGOP Equation 9.1 for landfills with comprehensive landfill gas (LFG) collection systems and EPA's subpart HH equations are essentially the same methodology. This inventory uses equation HH-8 from the EPA Mandatory Reporting Rule to calculate emissions from the Midway and Kent-Highlands landfills. The text from the equation is shown below.

Subpart HH

§ 98.343 Calculating GHG emissions.

(3) For landfills with landfill gas collection systems, calculate CH_4 emissions using the methodologies specified in paragraphs (c)(3)(i) and (c)(3)(ii) of this section.

ii) Calculate CH_4 generation and CH_4 emissions using measured CH_4 recovery and estimated gas collection efficiency and Equations HH–7 and HH–8 of this section.

$$Emissions = \left[\left(\frac{R}{CE \times F_{Rec}} - R\right) \times (1 - OX) + R \times \left(1 - (DE \times f_{Dest})\right)\right]$$

$$Emissions = \left[\left(\frac{R}{CE \times F_{Rec}} - R\right) \times (1 - OX) + R \times \left(1 - (DE \times f_{Dest})\right)\right]$$

Where:

MG = Methane generation, adjusted for oxidation, from the landfill in the reporting year (metric tons CH_4).

Emissions = Methane emissions from the landfill in the reporting year (metric tons CH_4).

R = Quantity of recovered CH_4 from Equation HH–4 of this section (metric tons CH_4).

CE = Collection efficiency estimated at landfill, taking into account system coverage, operation, and cover system materials from Table HH–3 of this subpart. If area by soil cover type information is not available, use default value of 0.75 (CE4 in table HH–3 of this subpart) for all areas under active influence of the collection system.

f_{Rec} = Fraction of hours the recovery system was operating (annual operating hours/8760 hours per year).

OX = Oxidation fraction. Use the oxidation fractions default value of 0.1 (10%).

DE = Destruction efficiency, (lesser of manufacturer's specified destruction efficiency and 0.99). If the gas is transported off-site for destruction, use DE = 1.

f_{Dest} = Fraction of hours the destruction device was operating (device operating hours/8760 hours per year). If the gas is destroyed in a back-up flare (or similar device) or if the gas is transported off-site for destruction, use f_{Dest} = 1.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

See the 2008 MDW worksheets “08-45 Landfill Raw Data” and “08-45 Landfill Final Data”.

For 2009, the relevant worksheets are “09-45 Landfill Raw Data” and “09-45 Landfill Final Data”.

Table 25 Solid Waste Landfills Data Sources

Source	Source File Year	
	2008	2009
SPU	08-45-3	09-45-5 Kent GHG work sheet-2009
SPU	08-45-4	09-45-6 Midway GHG work sheet-2009
SPU	08-45-5	09-45-8 Interbay up to 2009 green housev2.xls

5- Municipal Power Generation

Emission Sources

Emissions from the Municipal Power Generation sector result from fuels consumed for the production of electricity and/or heat and steam. Seattle City Light, a department of the City of Seattle, is one of the nation's largest municipally owned utilities in terms of the number of customers served. The power generation facilities operated by Seattle City Light are hydroelectric. In years with normal precipitation, Seattle City Light plants supply more than half of Seattle's power needs. The difference is made up by purchasing power from outside the region. The overall resource mix is over 90 percent hydroelectric, resulting in very low emissions.

Emissions from Municipal Power Generation are Scope 1.

Methodology

The information needed to quantify direct stationary combustion GHG emissions for Seattle City Light is readily available from the annual inventory produced by Seattle City Light in accordance with their reporting to The Climate Registry. It includes information on generation owned by SCL, energy purchases made by SCL, SF6 usage, transmission and distribution losses, offsets purchased, and entity-wide greenhouse gas emission factors.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

See the 2008 MDW worksheets "08-50 SCL Raw Data", "08-50 SCL Working Data", "08-50 SCL Final Data", "08-50 SCL T&D Loss Final Data" and "08-50 SCL SF6 Final Data".

For 2009, the relevant worksheets are "09-50 SCL Raw Data", "09-50 SCL Working Data", "09-50 SCL Final Data", "09-50 SCL T&D Loss Final Data" and "09-50 SCL SF6 Final Data".

Table 26 Municipal Power Generation Data Sources

Source	Source File Year	
	2008	2009
SCL	08-50-1 City Light Inventory as of 10.29.09	09-50-1 DRAFT - Sent to OSE (July 29, 2010)

6- Employee Commute

Emission Sources

Emissions from the Employee Commute Sector are the result of City of Seattle employees using either their personal vehicles or public transportation to commute to and from work. Emissions from the Employee Commute sector result from the combustion of mobile fuels in personal vehicles and transit vehicles, as well as electricity consumption to power transit vehicles. These are Scope 3 emissions.

Methodology

Employee commute is a Scope 3 emissions source. As such, there is no methodology specified by the LGO Protocol.

Washington State's Commute Trip Reduction (CTR) law requires employers with facilities housing 100 or more employees to survey commuting behavior biannually. The survey results are reported to King County, which archives the data in a standard format and forwards it to the Washington State Department of Transportation (WSDOT); WSDOT then processes the data to provide the city with commuting travel statistics for each qualifying facility.

The workbook provided by King County Metro contains employee commute information for City of Seattle work locations with over 100 employees. It identifies the number of employees at each site, the survey response rate, the percentage of employees who drive alone, take the bus, take the train, carpool, and vanpool. It also identifies the distance traveled for each mode, as well as the number of participants in each carpool or vanpool. Emissions resulting from transit usage were excluded from this analysis, as they are captured via inventory work undertaken by King County Metro.

The workbook contains the number of employees who work at each City of Seattle work location with more than 100 employees.

The total number of City of Seattle employees is 10,998, a percentage of which work at locations that were part of the survey. The mode share and distance traveled by each of the respondents were applied to all employees surveyed. So, for employees working at "Site A" who did not respond to the survey, their commutes were assumed to be the same as the average of those who did respond.

For the employees who worked at non-surveyed locations, their mode share and distance traveled were assumed to be the same as the average response of the respondents at the surveyed locations. The total number of non-surveyed employees is a line item on the "working data" sheets in the MDW. Total employees – surveyed employees = non-surveyed employees.

Calculation steps:

For both surveyed and non-surveyed work locations, annual vehicle miles traveled were calculated as follows:

Annual VMT = (Total Employees * Mode Share Percentage) * (One Way Distance * 2) * (Days Per Year – Holidays – Sick Days – Vacation Days)

For the carpool and vanpool modes, the number of occupants in each carpool or vanpool divided the above equation.

VMT was converted into fuel consumption using a fuel efficiency of 20 miles per gallon and assuming all fuel consumed was gasoline. The emission factor for gasoline is from LGO Protocol v1.1.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

See the 2008 MDW worksheets "08-60 Commute Raw Data", "08-60 Commute Working Data", and "08-60 Commute Final Data".

For 2009, the relevant worksheets are "09-60 Commute Raw Data", "09-60 Commute Working Data", and "09-60 Commute Final Data".

Table 27 Employee Commute Data Sources

Source	Source File Year	
	2008	2009
King County	08-60-1 Employee Commute Data	09-60-1 Employee Commute Data
Personnel	08-60-2 Employee count by jobtitle and location code 090210	09-60-2 Employee count by jobtitle and location code 090210

7- Employee Air Travel

Emission Sources

Emissions from the Employee Air Travel sector are the result of City of Seattle employee's use of flights on commercial airlines in the conducting of city business. Emissions from the Employee Commute sector result from the combustion of mobile fuels in commercial aircraft. These are Scope 3 emissions.

Methodologies

Employee Air Travel is a Scope 3 emissions source. As such, there is no methodology specified by the LGO Protocol. The ability of each jurisdiction to adhere to that guidance is dependent on existing practices and availability of data.

To calculate emissions from this source, the City of Seattle compiled departmental travel records. Departments reported the destination of flights and the number of staff per year that flew to a given location. Distances where computed an online mileage calculator at: http://www.webflyer.com/travel/mileage_calculator/. These flights were categorized as either short (less than 300 miles), medium (less than 700 miles), and long (over 700 miles). Emissions were estimated based on total miles flown per flight type using emission factors from EPA Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, May 2008.

The 2005 figure was originally reported as 710 metric tons and 1990 figure as 1,540 metric tons. To reflect changes in inventory guidance from EPA, these numbers have been recalculated using the latest emissions factors and are now reported as 2,300 metric tons and 5,060 metric tons.

Master Data Workbook

Notes on data entry and organization are provided on each MDW worksheet.

See the 2008 MDW worksheets "08-70 Air Travel Raw Data" and "08-70 Air Travel Final Data." For 2009, the relevant worksheets are "09-70 Air Travel Raw Data" and "09-70 Air Travel Final Data."

Table 28 Employee Air Travel Data Sources

Source	Source File Year	
	2008	**2009**
OSE	08-70-1 Employee Air travel	09-70-1 Employee Air travel

Heating Degree Day Calculations

Heating degree days are used to normalize the energy consumption of a heated building so that the normalized figures can be compared on a like-for-like basis.

Consumption of natural gas in buildings was calculated by normalizing the energy-consumption figures for the therms per degree day for 2005, 2008, and 2009.

Seattle Public Utilities publishes monthly degree day information for the City of Seattle. The figures are based on readings collected at the Seattle-Tacoma Airport Station. From 1971-2000, the annual average for HDD was 4,797. This was the figure that the HDD totals for 2005, 2008, and 2009 were normalized against.

Table 29 Heating Degree Days for 2005, 2008, and 2009

Inventory Year	Therms	Normalized Therms	HDD	Therms/HDD
2005	2,772,046	2,962,242	4,489	618
2008	2,925,451	2,772,301	5,062	578
2009	2,959,660	2,899,222	4,897	604

Table 3 shows that 2005 was a warmer than normal year, while 2008 and 2009 were both colder.

The therms per HDD is the result of dividing actual therms per year by the number of HDD in that year. To obtain normalized therms, multiply the therms per degree day by 4,797, the "normal" amount of HDD from 1971-2000.