City of Baltimore Greenhouse Gas Emissions Analysis

2007 Community Emissions Inventory & 2007 Government Operations Emissions Inventory

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Credits and Acknowledgements

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1. Introduction

On October 24, 2007, Baltimore City Mayor, Sheila Dixon, signed a City Council Bill 07-0834, committing the City to climate protection. Through this resolution, the City of Baltimore recognized that greenhouse gases emitted by human activity threaten Earth's climate; the City also affirmed the importance of beginning to reduce these emissions, both through refining government operations and through inspiring change in the broader community. With energy efficiency in its facilities and vehicle fleet, cleaner energy sources, waste reduction efforts, careful land use and transit planning the City of Baltimore can save energy and money, reduce emissions, and preserve quality of life in our community. With the assistance of ICLEI – Local Governments for Sustainability, the City has begun its efforts to measure and reduce greenhouse gas emissions.

This document represents Baltimore City's completion of the first step in this process: conducting an inventory of greenhouse gas emissions. Presented here are estimates of greenhouse gas emissions in 2007 resulting from our community as a whole, as well as those resulting from the City's internal government operations. These data will provide a baseline against which we will be able to compare future performance and track progress in emissions reductions.

1.1. Climate Change Background

A balance of naturally occurring gases dispersed in the atmosphere determines Earth's climate by trapping solar heat. This phenomenon is known as the greenhouse effect. Modern human activity, most notably the burning of fossil fuels for transportation and electricity generation, introduces large amounts of carbon dioxide and other gases into the atmosphere. Collectively, these gases intensify the natural greenhouse effect, causing the global average surface temperature to rise, and in turn, affecting global climate patterns.

In response to the threat of climate change, communities worldwide are reducing greenhouse gas emissions. The Kyoto Protocol, an international effort to coordinate mandated reductions, went into effect in February 2005, with 161 countries participating. The United States is one of three industrialized countries that refused to sign the Protocol. In the face of federal inaction, many communities in the United States are taking responsibility for addressing climate change at the local level.

Many of the projected impacts of climate change have potential to affect Baltimore in the future. Sea level rise, increased extreme weather events, and complex ecosystem changes all pose serious threats to future commerce and life in Baltimore City.

2. Greenhouse Gas Emissions Inventory

The Baltimore Sustainability Plan, released in 2009, outlines goals and specific strategies that will help Baltimore to avoid these adverse effects of climate change and to become a model of environmental stewardship. One primary goal of the Plan is a 15% reduction of Baltimore's greenhouse gas emissions by 2015. The first step toward reducing Baltimore City's greenhouse gas emissions is an assessment of baseline levels and sources of emissions, as well as the entities responsible for them. This information is intended to inform the selection of reduction targets and measures.

2.1. Methodology and Model

ICLEI's methodology provides a systematic framework for local governments to track energy- and waste-related activities in the community, and to calculate the amounts of greenhouse gases produced by each activity and sector. The inventory methodology involves two parts: a community-wide assessment and a separate inventory of government operations.

Once completed, these inventories provide the basis for an emissions forecast, and allow for the quantification of emissions reductions associated with proposed measures.

2.1.1. CACP Software

To facilitate community efforts to reduce greenhouse gas emissions, ICLEI joined forces in 2001 with the National Association of Clean Air Agencies (NACAA) and the U.S. Environmental Protection Agency (EPA) to build a software product to help local governments create greenhouse gas inventories, quantify the benefits of reduction measures, and formulate local climate action plans. This collaboration produced ICLEI's 2003 Clean Air Climate Protection (CACP) Software.

In 2008, ICLEI partnered with the California Air resources Board and the California Climate Action Registry to develop the Local Government Operations Protocol (LGOP) to guide local governments through a streamlined greenhouse gas emissions inventory process. ICLEI created an updated version of its software, CACP 2009, to support emissions inventorying and climate action planning based on the LGOP's principles and methods.

CACP 2009 is an emissions management tool that calculates and tracks emissions and reductions of greenhouse gases (carbon dioxide, methane, nitrous oxide) and criteria air pollutants (NOx, SOx, carbon monoxide, volatile organic compounds, PM10, PM 2.5) associated with electricity, fuel use, and waste disposal.

The CACP software determines emissions using specific factors (or coefficients) according to fuel type. The emissions coefficients and methodology employed by the

CACP software are consistent with national and international inventory standards outlined in the LGOP. Greenhouse gas emissions are aggregated and reported in terms of equivalent carbon dioxide units, or CO2e, which allows for the assessment of different greenhouse gases in comparable terms. For example, methane is twenty-one times more powerful than carbon dioxide on a per molecule basis in its capacity to trap heat, so one ton of methane emissions would be 21 tons of carbon dioxide equivalents. The CACP software reports input and output data in several formats, including detailed, aggregate, source-based and time-series reports. The CACP software has been used by over 350 U.S. cities, towns, and counties.

Although the software provides the City of Baltimore with a sophisticated and useful tool, calculating emissions from energy use with precision is difficult. Because the model depends upon numerous assumptions and limited data, any specific number generated by the model should be viewed as an approximation of reality, rather than an exact value.

2.2.2. Creating the Inventory

Our greenhouse gas emissions inventory consists of two essentially distinct inventories: one for the Baltimore City community as a whole, defined by our geographic borders, and one highlighting emissions resulting from the City of Baltimore's internal government operations. The Government Inventory is a subset of the Community Inventory (emissions from the municipal operations are embedded in the community inventory). Distinguishing the municipal emissions in this way allows the City Government, which formally committed to reducing emissions, to lead by example in tracking its individual facilities and vehicles and evaluating the effectiveness of its emissions reduction efforts.

Compiling Baltimore City's emissions inventory required the collection of information from a variety of sources. Data are from 2007, except where notes indicate data gaps that necessitated use of older records.

For our scope, emissions associated with energy consumed in Baltimore City are included, regardless of the location of the original energy source. This means that, even though the electricity used by Baltimore residents is produced in a plant outside of Baltimore City's geographical borders, this energy and the emissions associated with it appear in Baltimore City's inventory. The decision to capture emissions in this way reflects the general philosophy that a community should take full responsibility for the impacts associated with its energy consumption, regardless of where the energy generation occurs.

2.2. Inventory Results

2.2.1. Community Emissions Inventory

CACP separates the community into five sectors: Residential, Industrial, Commercial, Waste, and Transportation. In 2007, the community of Baltimore City—these five sectors combined—emitted approximately 9,226,075 tons of CO2e. As shown in Table 1 and illustrated in the pie chart below, the Industrial, Transportation, Residential, and Industrial sectors each contributed roughly a quarter of the city-wide emissions. The Waste sector was responsible for the lowest level of emissions, contributing only 2.9% of the total.
The relatively small footprint of Baltimore's solid waste can be explained by the fact that most of Baltimore waste is incinerated and converted to energy, not dumped in a landfill.

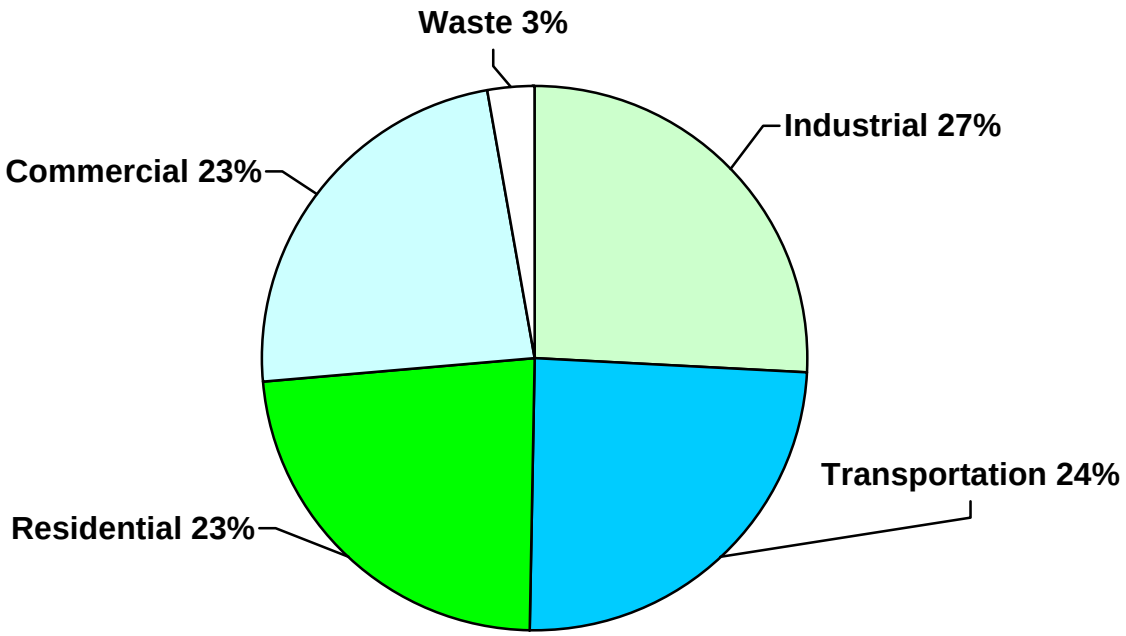
Transportation's large footprint reflects Baltimore City's poor public transit system and reinforces the City's recent focus on improvements in this area. The Sustainability Plan targets this sector with specific strategies to improve Baltimore's public transit and educate citizens on the most efficient ways to move throughout the City.

The Plan also offers solutions for the other four sectors, outlining outreach to industries, businesses, and homeowners in a holistic approach to emissions reduction.

Table 1: City of Baltimore Community-Wide Greenhouse Gas Emissions in 2007

Sector	Greenhouse Gas Emissions (tons CO_2e)	Share of Net CO_2e emissions (%)
Industrial	2,382,109	25.8
Transportation	2,254,410	24.4
Residential	2,166,818	23.5
Commercial	2,157,649	23.4
Waste	265,088	2.9
Total	**9,226,075**	**100**

Figure 1. Baltimore City Greenhouse Gas Emissions in 2007 by Sector



The Baltimore City community's consumption of electricity and other fuels in local buildings and vehicles is also responsible for the release of criteria air pollutants, including NO_X, SO_X, CO, VOCs, and PM_{10}. The Transportation sector is responsible for the majority of CO and VOC emissions, while energy used in buildings is primarily responsible for emissions of SO_X and PM_{10}. All sectors contributed large shares of NOx.

Table 2. 2007 Baltimore City Community-Wide Criteria Air Pollutant Emissions

Sector	**NO_X** (mlbs)	**SO_X** (mlbs)	**CO** (mlbs)	**VOCs** (mlbs)	**PM_{10}** (mlbs)
Residential	18.7	12.8	4.49	1.29	1.90
Commercial	13.3	17.2	3.44	0.836	1.83
Industrial	11.7	18.5	3.32	0.625	1.60
Transportation	13.9	0.790	112	11.5	0.375
Total	**57.6**	**49.3**	**123**	**14.2**	**5.71**

2.2.2. Government Emissions Inventory

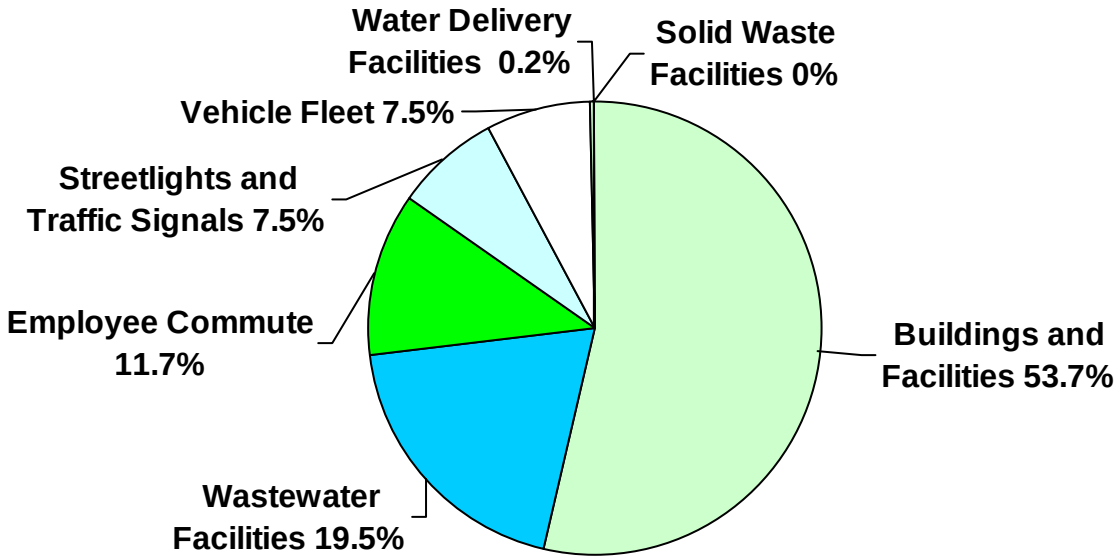
In 2007, the City of Baltimore's government operations generated 608,988 tons of CO2e. The City's government buildings, streetlights, and vehicle fleet contributed roughly similar fractions of this total, with the vehicle fleet responsible for the largest share of greenhouse gas emissions.

During 2007, the City Government spent approximately 75,297,533 on energy-related expenses for its facilities, streetlights, and vehicles. Beyond reducing harmful greenhouse gases, any future reductions in government operations' energy use have the potential to reduce this expense, enabling the City of Baltimore to reallocate its limited funds. Table 3 and Figure 2 below illustrate the breakdown of government operations emissions by source type.

Table 3: Baltimore City Government Operations Emissions Summary

Sector	Greenhouse Gas Emissions (tons CO2e)	Share of Net Government Emissions (%)	Cost (million $)
Buildings and Facilities	326,908	53.7	38,065,850
Wastewater Facilities	118,698	19.5	13,506,571
Employee Commute	71,128	11.7	---
Vehicle Fleet	45,450	7.5	10,079,029
Streetlights & Traffic Lights	45,337	7.5	13,403,230
Water Delivery Facilities	1,090	0.2	216,827
Solid Waste Facilities	116	0.0	10,079,029
TOTAL	**608,988**	**100**	**75,297,533**

Figure 2. 2007 Baltimore City Government Greenhouse Gas Emissions



The City of Baltimore was also responsible for the release of criteria air pollution in 2007, as shown below. These pollutants have been linked with various environmental and public health outcomes; many of the measures to decrease greenhouse gas emissions will reduce these pollutants as well.

Table 2. 2007 Baltimore City Community-Wide Criteria Air Pollutant Emissions

Sector	**NO_X** (lbs)	**SO_X** (lbs)	**CO** (lbs)	**VOCs** (lbs)	**PM_{10}** (lbs)
Buildings and Facilities	821,569	1,747,949	235,371	43,930	153,316
Vehicle Fleet	229,659	17,354	1,739,075	200,513	11,400
Streetlights & Traffic Signals	132,302	507,159	44,363	4,983	38,576
Water Delivery Facilities	3,163	7,949	976	138	635
Wastewater Facilities	344,316	1,284,340	114,733	13,132	97,949
Employee Commute	419,788	22,901	4,740,896	477,199	10,243
Solid Waste Facilities	336	916	105	14	72

Government operations CO_2e emissions in City of Baltimore constitute about 6.6% of the community's total greenhouse gas emissions. This is slightly above average; local government emissions typically account for around two percent of community levels. As a relatively minor contributor to total emissions, actions to reduce government operations energy use will have a limited impact on the City of Baltimore community's overall emissions levels. However, as previously mentioned, government action has symbolic value that extends beyond the magnitude of emissions actually reduced.

3. Conclusion

In signing the US Conference of Mayors' Climate Protection Agreement in 2006, Mayor Sheila Dixon formally committed to reducing Baltimore City's greenhouse gas emissions. This report lays the groundwork for those efforts by estimating baseline emissions levels against which future progress can be measured.

This analysis found that the City of Baltimore community as a whole was responsible for emitting 9,226,075 tons of CO_2e in 2007. The residential, industrial, commercial and transportation sectors each contributed roughly a quarter of this total. Baltimore City Government operations were responsible for 608,988 tons CO_2e 2007, accounting for 6.6 percent of the community's total greenhouse gas emissions.

The Baltimore Sustainability Plan calls for a 15% reduction in citywide greenhouse gas emissions by 2015. The Sustainability Plan also outlines numerous emissions reduction measures that address all sectors of this inventory. The City of Baltimore will next complete a Climate Action Plan which will include forecasts of anticipated future emissions. The City will also begin documenting emissions reduction measures implemented since the base year documented in this report and quantifying the emissions benefits of these measures.

The City of Baltimore's Office of Sustainability and Commission on Sustainability will continue to advise and support Mayor Dixon and City Council in continuing Baltimore City's climate protection efforts.

Appendix 1: Assumptions and Background

I. Software Settings

Clean Air, Climate Protection Software (CACP) offers users the choice to rely on default figures for efficiency and emissions measurements or to enter region- or facility-specific data. Baltimore's 2007 inventory applied EPA's default regional electricity coefficients in most cases. BGE-specific kerosene coefficients, however, outlined in BGE's Residential Fuel Oil Reports, replaced defaults where kerosene was a fuel type. The kerosene coefficients we added are: 1.08 lbs/gal for PM10, 43.20 lbs/gal for SOx, 18.00 lbs/gal for NOx, 5.00 lbs/gal for CO, and 0.71 lbs/gal for VOC.

II. Community Inventory

Emissions associated with the Residential, Commercial, and Industrial sectors were measured in terms of energy consumption. Natural gas and electricity data came from BGE's 2007 records. Oil and kerosene data came from MDE Air and Radiation Management Administration for the year 2002; because no more recent figures were available, these 2002 data were entered.

a. Residential
    - Data for 245,212 BGE electric accounts were summed and entered with grid average electricity as fuel type.
    - Data for 206,229 BGE natural gas accounts were summed and entered with natural gas as fuel type.
    - Data for 39,172 dwelling units (provided in an aggregate gallons figure) using #2 heating oil were summed and entered into CACP with fuel oil (1, 2, or 4) as fuel type.

b. Commercial
    Six data entries were provided for this sector. Each represents a distinct type of commercial account and is an aggregate figure of all energy consumption by consumers with that type of account.
        - "G: 'Small Commercial' BGE" electric accounts; this classification is used for accounts with a monthly demand below 60 kW. BGE reported 24,835 "G" accounts.
        - "GL: 'Large Commercial' BGE" electric accounts; this classification is used for accounts with a monthly demand of at least 60 kW. BGE reported 2,226 "GL" accounts.
        - "CL: 'General Service Large' BGE" natural gas accounts; this classification is used for accounts with a monthly demand below 9,000 therms. BGE reported 1,597 "CL" accounts.
        - "C: 'General Service' from BGE" natural gas accounts; this classification is used for accounts with a monthly demand of at least 9,000 therms. BGE reported12,249 "C" accounts.
        - "Commercial #2 Oil" accounts; unknown number of accounts.
        - "Commercial Kerosene" accounts; unknown number of accounts.

c. Industrial

Five aggregated data entries were included this sector. Each represents a distinct type of industrial account and is an aggregate figure of all energy consumption by consumers with that type of account:

- "P: 'Primary Voltage' BGE" electric accounts; this classification is used for accounts with time-of-use service. Customers with this type of account demand constant electricity availability. BGE reported 160 "P" accounts.
- "IS: 'Interruptible Service' from BGE" accounts; this classification is used for accounts with service that can be interrupted during BGE's peak hours. BGE reported 72 "IS" accounts.
- "Industrial #2 Oil" accounts; unknown number of accounts.
- "Industrial Kerosene" accounts; unknown number of accounts.
- "Residual Fuel Oil" accounts; unknown number of accounts.

d. Transportation

The Baltimore Metropolitan Council provided 2007 data (extrapolated from 2000 and 2008 records) on vehicle miles traveled on roads within Baltimore City. Vehicles were classified into categories and fuel types: grouped first by fuel source (diesel or gasoline), vehicles were then recorded as heavy duty vehicles, light trucks, or passenger cars. The software also asks for vehicle model year. Because data on vehicle model year were not available, all vehicles were entered into CACP software as "alternative method." This indicates that an average efficiency figure of comparable vehicles (i.e. light trucks) on the road in 2007 is applied, instead of a particular efficiency from a given year.

Motorcycles were classified as gas passenger vehicles, per ICLEI's advice, as this was the most relevant category offered. Motorcycles, however, are generally much more efficient than cars, so emissions from these vehicles are likely overestimated.

It is important to note that this scope does not account for net transportation emissions of Baltimore residents. Rather, it includes emissions of all vehicles that traveled within Baltimore City geographical borders in 2007, regardless of the vehicle's jurisdiction of origin. Thus, municipal efforts to reduce automobile use by City residents might not be reflected accurately in later inventories for two reasons: first, City resident driving habits are not the only factors in the calculation, and second, automobile travel by City residents is not restricted to City roads.

Use of light rail, metro, air, and boat travel was not accounted for in this inventory due to lack of available data.

e. Waste

Six categories of data were recorded:

- tonnage sent from the Baltimore City Bureau of Solid Waste to Baltimore Refuse Energy Systems Company (BRESCO)
- tonnage sent from Northwest Transfer Station (NWTS) to BRESCO
- tonnage sent from other Baltimore City agencies to BRESCO
- tonnage sent from Routine Services to BRESCO
- tonnage sent from Special Services to BRESCO
- tonnage sent to Quarantine Road Sanitary Landfill (QRSL)

The waste accounted for in this inventory includes waste delivered to the Baltimore Refuse Energy Systems Company (BRESCO) and the Quarantine Road Sanitary Landfill (QRSL).

The BRESCO facility, which receives the majority of Baltimore City's mixed refuse, burns refuse to produce steam and 55 Megawatts of electricity. At full capacity, BRESCO can produce 510,000 pounds of steam per hour and up to 60,000 kilowatts of electricity per hour. QRSL accepts mainly inorganic material, including BRESCO ash, water and wastewater ash and grit, industrial debris, and City-hauled construction and demolition debris.

City waste haulers and private firms share the responsibility of collecting Baltimore City trash. While City haulers pick up waste created only in Baltimore City, private haulers collect waste from with the City and surrounding jurisdictions. Waste acceptance facilities do not segregate these groups of waste, so it is difficult to know how much waste originates in each jurisdiction. Because the figures also include waste produced outside of Baltimore City, the emissions from City waste are likely overestimated here.

Further overestimation may result from double counting emissions from the BRESCO facility. Electricity produced by BRESCO goes primarily into the regional electricity grid mix. Consumers in the residential, commercial, and industrial sectors purchase this electricity, and the emissions associated with producing this electricity are recorded in the sectors' respective inventories. The double counting of these emissions occurs when, in the inventory software's Waste tab, emissions from waste disposal at BRESCO are measured. This disposal is, in fact, the process through which BRESCO produced the energy and associated emissions already accounted for in the residential, commercial, and industrial tabs.

To separate tonnage into waste types, the percentages provided in the Local Government Operations Protocol (LGOP) for the year 2003 were applied. No more recent data were available. Since these categories were not identical to those used in the CACP software, some adjustments were necessary. More specifically, for CACP's *Paper Products field*, we added percentages the LGOP listed for newspaper (1.4%), office paper (14.1%), corrugated boxes (9.3%), and coated paper (1.4%) to get 26.2%. For the *Food field*, we entered the percentage given, 16.4%. For the *Plant Trimmings field*, we summed data for grass (3.8%), leaves (1.9%), and branches (1.9%) for a total of 7.6%. For the *Wood/Textiles field*, we added numbers provided for lumber (7.5%) and textiles (6.0%) for a sum of 13.5%. According to the default figures, these four main categories account for 63.7% of waste, leaving 36.3% in *Other*.

Paper Products	Office paper	Corrugated boxes	Coated Paper	Newspaper	Total
	14.1%	9.3 %	1.4%	1.4%	**26.2%**
Food	Food				Total
	16.4 %				**16.4%**
Plant Trimmings	Grass	Leaves	Textiles		Total
	3.8%	1.9%	6%		**7.6%**
Wood/textiles	Lumber	Textiles			Total
	7.5%	6%			**13.5%**
Other	Diapers	Construction/ Demolition	Other		Total
	16.4%	7.6%	29%		**36.3%**

III. Government Inventory

a. Buildings and Facilities
The Baltimore City Department of Public Works Accounting Office (DPWAO) provided natural gas, electricity, and fuel oil records for this scope. 715 entries appear in this sector of the inventory, accounting for buildings the City owns and occupies and buildings the City owns but does not occupy. Buildings associated with the Baltimore City Public School System (BCPSS) are included here. Two entries report aggregate use of chilled water and steam. These figures were determined using default efficiency factors provided by the LGOP and steam enthalpy figures provided by the utility. Comfort Link provides Baltimore's chilled water, and Trigen provides steam. Another entry accounts for aggregate fuel oil data. All other facilities were entered separately to allow for clear comparison of energy consumption.

b. Streetlights and Traffic Signals
Energy use data came from the Baltimore City DPWAO. 28 accounts were entered into this sector, although traffic signals were clumped into a single entry due to lack of more specific records.

c. Water Delivery Facilities
The DPWAO also supplied data for this sector, in which there are 18 accounts.

d. Wastewater Facilities
These data, provided by the DPWAO, total 87 accounts. DPW water treatment, storm water, and wastewater records were all entered into this sector.

e. Vehicle Fleet
This sector contains fuel use data for fleets of 104 City bureaus. The Central Garage's Fleet Management Division provided data on gallons of fuel consumed.

f. Solid Waste Facilities
Two of Baltimore's waste disposal facilities are owned by the City of Baltimore: Northwest Transfer Station and Quarantine Road Sanitary Landfill. Accounts of energy consumption by these two facilities were entered in this tab.

g. Employee Commute
These data came from results of a City employee survey on commuting habits. Traci McPhail, of the Baltimore City Department of Transportation, and the Baltimore City Labor Commissioner's Office distributed this survey in May 2008, in conjunction with Baltimore's Clean Commute Month. According to McPhail, the survey went out to all City employees through email and through hand delivery to sites in the field. All City employees (including city schools staff) total 29,393 people; 2,439 completed surveys were received. Responses to two key questions, "How did you travel to work each day last week?" and "How many miles do you travel to work one-way?" were analyzed for this inventory. Based on the assumption that the data collected reflect general trends throughout the entire City employee community, extrapolation provided a figure accounting for the commutes of all 29,393 employees. Survey responses indicated an average one-way commute of 13.74 mi.

Calculations were performed with the following assumptions:
- Baltimore City Public Schools System (BCPSS) staff work 190 days/year.
- Non-BCPSS staff work 240 days/year.

Only emissions resulting from driving by City employees were recorded in this inventory. Emissions from public transit operation are not included for two reasons; first, survey respondents did not distinguish among modes of transit, and second, trends in automobile use are excellent, if indirect, indicators of changes in public transit ridership.

h. Notable Exclusions

i. Transit Fleet
The Maryland Department of Transportation operates Baltimore City's public transit modes (buses, light rail, subway), so related emissions do not fall under the Baltimore City scope. The City is considering adding some transit options under its own jurisdiction; upcoming inventories will account for these modes. Urban buses are included in the community-wide inventory

ii. Port
Baltimore's port is also under Maryland State governance, so its emissions are not included in this inventory. Baltimore City plans, however, to look into incorporating port activities into future municipal inventories, as the port represents a major source of emissions in downtown Baltimore.

iii. Stationary Combustion
The MD Department of the Environment compiled a 2002 "Area Source Base Year Inventory" with a list of stationary combustion sites and their emissions of NH3, NOx, PM2.5, PM10, SO2, SOx, and VOC.
http://www.mde.state.md.us/assets/document/Air/BNAA_3-24-08/Appendices/Appendix_A-4.pdf
(http://www.mde.state.md.us/Programs/AirPrograms/air_planning/index.asp)