Baseline Inventory of Greenhouse Gas Emissions

for the

Metropolitan Government of Nashville and Davidson County

February 2009

Prepared By:

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and

GRESHAM
SMITH AND
PARTNERS

Acknowledgements

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Glossary

Atmosphere
The mixture of gases surrounding the Earth, which consist of approximately 80% nitrogen, 20% oxygen, and trace amounts of other gases. The atmosphere is divided into layers (i.e., stratosphere, troposphere) according to its mixing or chemical characteristics.

Baseline Greenhouse Gas Inventory
An estimation of greenhouse gases that are either released into or removed from the atmosphere over a defined period of time (usually 1 year). Municipalities commonly estimate emissions from both municipal operations (activities that generate greenhouse gas emission from buildings, vehicle fleet, employee commute, streetlights, and water/sewage activities) and community operations (Activities that generate greenhouse gas emissions from residential, commercial, industrial, transportation, and waste activities). Municipal greenhouse gas operations are a subset of community operations.

Carbon Cycle
The carbon cycle is a biogeochemical cycle by which carbon is exchanged through chemical, physical, geological, and biological processes.

Carbon Sequestration
The capture of carbon from the atmosphere and resultant long-term storage (i.e., biomass, dissolved carbon in oceans, etc.). This is also commonly referred to as a carbon sink.

CO_2 Equivalents (CO_2e)
A unit that converts emissions of different greenhouse gases of varied strengths so they can be added together or compared by calculating their comparative strength to CO_2.

Emission
A gas that is released into the atmosphere.

Emission Source and Distribution
The origin of a gas emission and allocation of sources.

Fossil Fuel
A general term for buried combustible geologic deposits of organic material, formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the Earth's crust over millions of years.

Global Climate Change
Long-term change in the average weather of the Earth. Average weather may include average temperature, precipitation and wind patterns, and involve variability within the atmosphere over a period of time (typically thousands to millions of years).

Global Warming Potential (GWP)
A term used to describe the amount a greenhouse gas has the potential to impact global warming. Some greenhouse gases are significantly more potent than carbon dioxide and are known to persist in the atmosphere for hundreds of years.

Greenhouse Gas
A gas that absorbs infrared radiation, which results in the trapping and buildup of heat in the atmosphere. Primary greenhouse gases include:

- ***Carbon Dioxide (CO_2)***
  Carbon dioxide is released into the atmosphere by animal respiration, decay of organic matter, and fossil fuel burning. Carbon dioxide is removed from the atmosphere by photosynthesis of plants.

- ***Chlorofluorocarbons (CFCs)***
  Chlorofluorocarbons are released into the atmosphere from industrial processes. They are synthetic compounds comprised of chlorine and fluorine.

- ***Methane (CH_4)***
  Methane is a colorless, nonpoisonous, flammable gas released into the atmosphere by anaerobic decomposition of organic material. It is also the primary component of natural gas.

- ***Nitrous Oxide (N_2O)***
  Nitrous oxide is released into the atmosphere by combustion of fossil fuels, use of commercial and organic fertilizers, nitric acid production, and burning of biomass.

ICLEI Clean Air and Climate Protection (CACP) Software
Software used to develop the Nashville and Davidson County baseline greenhouse gas inventory.

Kilowatt Hour (kWh)
A standard metric unit for measurement of electricity that is equal to work being done by a power of 1,000 watts operating for one hour.

Parts Per Million (ppm)
A common unit of measure used to express the number of parts of a substance contained within a million parts of a liquid, solid, or gas.

Sustainability
According to the Environmental Protection Agency, sustainability means “meeting the needs of the present without compromising the ability of future generations to meet their own needs.”

Vehicle Miles Traveled
The number of miles traveled by selected vehicles over a specified period of time.

Executive Summary

Mayor Karl Dean is a signatory to the United States Mayor's Climate Protection Agreement, a voluntary commitment to reduce greenhouse gas (GHG) emissions by 7% below 1990 levels by 2012. This agreement has been signed by more than 900 Mayors across the United States representing over 81.8 million citizens. Subsequently, Mayor Dean issued Executive Order No. 033 on June 19, 2008, establishing a Green Ribbon Committee on Environmental Sustainability. The Green Ribbon Committee includes 26 citizen leaders appointed by the Mayor to recommend goals and actions Metro can take to become a leader in environmental quality. Additionally, Nashville joined ICLEI - Local Governments for Sustainability, a non-profit organization designed to assist local governments in GHG emission inventories and sustainability planning.

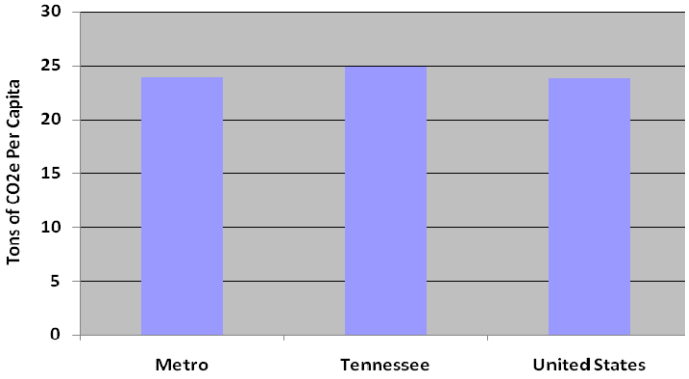
To begin recommendations for GHG-related goals and associated policies, Nashville Electric Service commissioned Gresham, Smith and Partners to work with the Department of Health to inventory existing Metropolitan Government of Nashville and Davidson County (Metro) GHG sources to provide an understanding of its emission sources and distribution. The Metro GHG baseline emissions inventory was also conducted to develop a baseline for which environmental efforts can be measured and indicate where improvement may be needed. Information for the GHG baseline emissions inventory was collected from various local utilities, Metro government operations and employees, as well as Metro Nashville Public School (MNPS). The following information presents the results of the GHG baseline emissions inventory for Metro's municipal and community operations.

Nashville and Davidson County community produced approximately 14.4 million tons of CO_2 equivalents (CO_2e) in 2005. The sectors producing these emissions are as follows from greatest to least: electric use for residential, commercial and industrial (62.4%); transportation (32.6%); waste generation and disposal (4.0%); and methane emissions from closed landfills (1.0%). Using a 2005 population of 602,679, the tons of CO_2e per capita is 23.9. This is similar to estimates from the United States overall (23.8) and lower than estimates from the state of Tennessee (24.9)[1] (**Figure 1**).

Figure 1

[1] World Resources Institute. Climate Analysis Indicators Tool. 2009. Retrieved January 2009, from http://cait.wri.org/

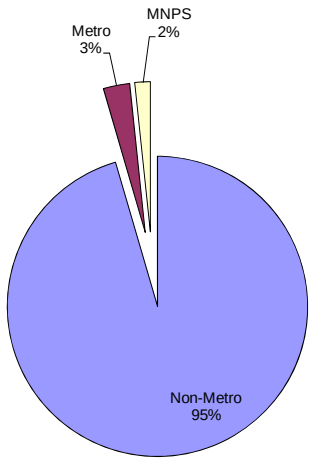
Local, State, and National Greenhouse Gas Emissions



Metro Government, a subset of the Nashville and Davidson County community, produced 649,417 tons of CO_2e. The highest emitter for Metro government was energy use in buildings which accounted for 43.5% of the total CO_2e emissions. This was followed by 21.5% for energy use by water/sewage services,[2] 15.3% for employee commute, 15.2% for the Metro vehicle fleet, 4.1% for waste generation and disposal, and 0.5% for streetlights. The results of the GHG analyses identified Metro municipal operations contribute to approximately 3.0% of the total CO_2e emissions for Nashville and Davidson County.

The MNPS data is displayed as a subset of the Metro Government data so that varying reduction efforts can be tracked both independently and as a total. MNPS operations generated a total of 239,319 tons of CO_2e, which accounts for 36.9% of the total municipal emissions. Energy consumption totaled 35.7% of the total municipal energy consumption. Total MNPS operations contributed to approximately 2.0% of the total CO_2e emissions (**Figure 2**).

Figure 2
2005 Metro vs. Community Greenhouse Gas Emissions



[2] Water/sewage is typically analyzed separately because the operations usually contribute to a higher percentage of energy use within government operations.

Introduction

Global Climate Change

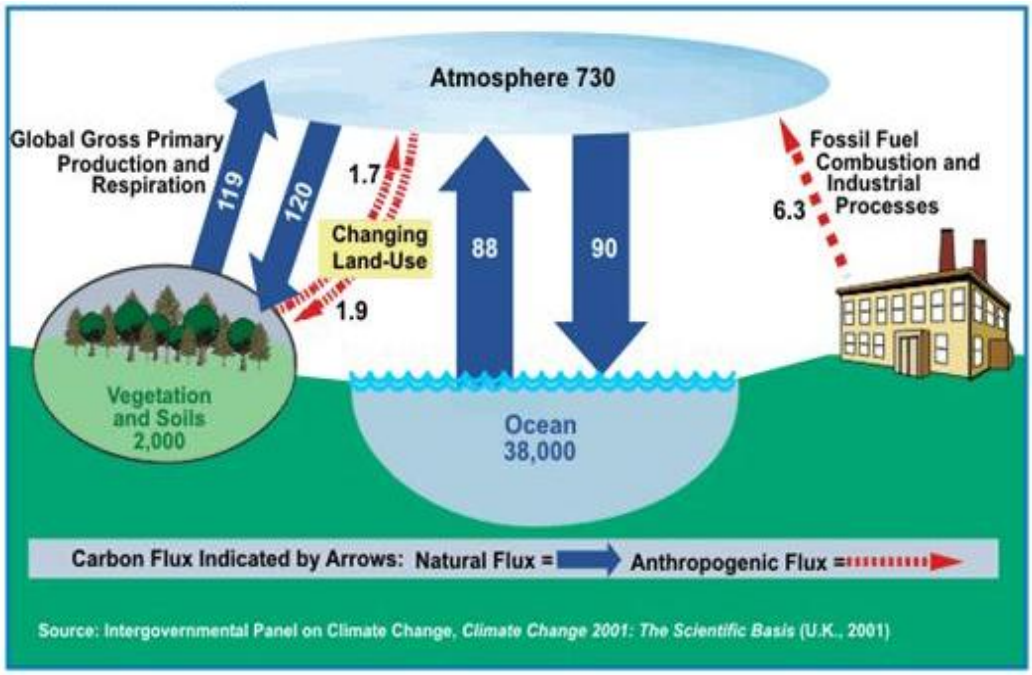
Global climate change is not a new phenomenon in the Earth's geologic history and scientists have analyzed changes in the Earth's temperature dating back millions of years. The Earth has repeatedly cooled (commonly called ice ages) and heated due to a variety of causes such as changes in the Earth's orbit, volcanic eruptions, and changes in the sun's intensity. However, according to a 2006 study conducted by the National Research Council, the global average temperature in the past several decades was warmer than any other time period in the last 400 years. Additionally, temperatures at many weather measuring stations were higher in the last 25 years than any time period measured since A.D. 900.

Figure 3, from the Intergovernmental Panel on Climate Change (IPCC), presents a conceptual interpretation of the Carbon Cycle. GHG emissions result from activities such as the burning of fossil fuels, land clearing and agricultural activities, as well as the generation of methane from landfills. Once emitted, GHGs allow light to pass through the atmosphere, but then trap heat and prevent it from escaping into space causing a "greenhouse" effect and subsequent warming of the Earth's surface. The GHGs of primary concern include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs) in the atmosphere. While there are other GHGs, these are the primary sources of concern to Metro due to the nature of its activities and associated community emissions. The following summarizes the sources of each of these GHGs according to the Environmental Protection Agency (EPA):

- CO_2 is emitted from the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products. CO_2 is also the result of chemical reactions in industrial processes.
- Methane or CH_4 is emitted from the production and transport of fossil fuels such as coal and natural gas as well as livestock, agriculture operations, and the decay of organic waste in solid waste landfills.
- Nitrous oxide or N_2O is emitted from industrial activities agricultural operations and the burning of fossil fuels and solid waste.
- Chlorofluorocarbons or CFCs are emitted from industrial processes such as the chemicals used for the replacement for ozone-depleting substances.

Figure 3

The Carbon Cycle



It is also important to recognize that each of these pollutants do not impact climate change in exactly the same way. Some GHGs, referred to as high Global Warming Potential (GWP) gases, are 140 times or more potent than CO_2, according to the EPA. Additionally, these high GWP gases are also known to persist in the atmosphere for hundreds of years, further complicating our ability to positively impact climate change. CO_2, for example, is known to persist in the atmosphere for 50 to 200 years. Therefore, an emission of CO_2 today could still be in existence for another century. **Table 1** is a listing of the GWP of various GHGs:

Table 1
Global Warming Potential of Various GHGs[3]

Gas	Global Warming Potential
Carbon Dioxide (CO2)	1 (Equivalent)
Methane (CH4)	21
Nitrous Oxide (N2O)	310
HFC-23	11,700
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-43-10mee	1,300
Perfluoromethane (CF4)	6,500
Perfluoroethane (C2F6)	9,200
C3F8	7,000
C4F10	7,000
C5F12	7,500
C6F14	7,400
Sulfur Hexafluoride (SF6)	23,900

Recording of GHG levels in the atmosphere in parts per million (ppm) has been conducted by Federal Agencies to determine the presence and level of GHGs since before industrial times starting in 1750. Concentrations of GHGs in the atmosphere in pre-industrial times from natural emission sources were approximately 280 ppm. However, according to the National Oceanic and Atmospheric Administration (NOAA), in 2006, the concentration of GHG in the atmosphere was 382 ppm, a 36% increase.

[3] The California Air Resources Board, The California Climate Action Registry, ICLEI- Local Governments for Sustainability, The Climate Registry. Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions Inventories, Version 1.0. September 2008.

Without concerted action, most GHG sources are expected to increase in the future. However, many new and cleaner technologies are on the horizon that will assist in mitigating these increases. Additionally, everyday choices concerning the type of vehicle we purchase, the amount of water and electricity we use, and the amount of waste we avoid generating or that we recycle, could drastically decrease the amount of GHG generated and emitted into the Earth's atmosphere.

Climate change resulting from GHGs has been, and continues to be studied by a variety of scientific organizations including the Intergovernmental Panel on Climate Change (IPCC), EPA, United States National Research Council, and various university programs across the planet. The results of these studies indicate even relatively small changes in the Earth's surface temperature can have significant impact including, but not limited to the following:

- Increased number of disease-carrying insects
- Increased ground level ozone concentrations, resulting in respiratory illnesses and difficulties
- Melting of polar ice caps, resulting in increased sea level and seasonal flooding
- Increased number and severity of storms
- Decreased water quantity and water quality

To begin addressing GHG emissions, most organizations develop a baseline GHG emissions inventory (GHG inventory). A GHG inventory is an estimation of GHGs that are either released to the atmosphere or removed from the atmosphere over a defined period of time, usually one year. Inventories assist an organization in determining the largest emitters of GHGs, developing associated strategies to reduce these emissions, and tracking progress on GHG reductions.

Response to Climate Change

Federal Response

EPA has recently implemented several programs promoting GHG emission reduction strategies, such as ENERGY STAR ratings, Clean Energy-Environment State Partnerships, and the Sustainable Skylines Initiative.

In July 2008, EPA published the Advance Notice of Proposed Rule Making (ANPR) in response to the *Massachusetts v. EPA* United States Supreme Court decision in which several states petitioned EPA to regulate GHG emissions from new mobile sources. The ANPR requested public comment on utilizing the Clean Air Act to regulate GHGs emissions from both mobile and stationary sources. The public comment period ended on November 28, 2008 and EPA is currently reviewing comments and evaluating information for proposed rulemaking. Federal legislative action and/or regulation on GHGs is expected to occur in the near future.

State Response

Many states have passed legislation regarding climate change, including requirements to study climate change impacts, conduct state-wide GHG emission inventories, and/or establish state-wide commissions on climate change. Additionally, there are several

regional associations working collaboratively to address climate change. For example, the Regional Greenhouse Gas Initiative (RGGI) of the Northeastern and Mid-Atlantic states evaluated GHG emissions from electrical power plants and established a market-based regional cap and trade emission program with the first sale of credits occurring in September 2008. Other associations are working together to create greenhouse gas registries and reporting programs.

The Tennessee Department of Economic and Community Development, in collaboration with other state agencies, completed a report in April 1999 entitled *Tennessee Greenhouse Gas Emissions Mitigation Strategies*. The document evaluated Tennessee's GHG emissions and presented policy options and actions that could be implemented to limit potential GHG impacts and make progress toward economic, energy, and environmental goals. This document was one of the first of its kind for the state and initiated concepts for state agencies to consider.

The Tennessee Department of Environment and Conservation, Division of Solid Waste Management signed a Memorandum of Understanding with the EPA, making the department a state ally to promote the Landfill Methane Outreach Program (LMOP). The LMOP is part of a nationwide strategy to stabilize GHG emissions and to meet the state of Tennessee's economic, energy, and environmental objectives.

Municipal Response

The most active response to climate change and reduction of GHGs emissions has been at the local level. Many cities, in the United States and abroad, are evaluating opportunities to not only reduce GHG emissions from municipal sources, but also to reduce the broader community sources of GHG emissions. Community sources of GHG emissions include, but are not limited to, residential energy use, industrial sources, and/or commuting emissions. To demonstrate Metro's commitment to reduce GHG emissions and associated global climate change impacts, Mayor Karl Dean is a signatory to the United States Mayor's Climate Protection Agreement, which has been signed by more than 900 Mayors across the United States representing over 8.8 million citizens.

Mayor Dean issued Executive Order No. 033 on June 19, 2008 establishing a Green Ribbon Committee, to make recommendations on how Nashville and Davidson County can improve its energy and environmental impact. The Green Ribbon Committee includes industry, environmental, and academic citizen leaders from across Nashville and Davidson County. Mayor Dean also established a sustainability officer within the Mayor’s Office to work collaboratively with the Committee and guide Metro’s sustainability efforts. Nashville and Davidson County will be able to use this GHG inventory as a baseline from which they can measure progress. To facilitate the assessment of GHG emissions, Metro joined ICLEI - Local Governments for Sustainability, a non-profit organization designed to assist local governments in GHG emission inventories and sustainability planning.

GHG Baseline Emissions Inventory

Methodology

The purpose of the Metro GHG inventory was to establish a baseline inventory of GHG emissions that could be used to understand the relative importance of addressing GHGs from various emission categories, determine the relative distribution of GHG emissions

for a variety of sources, and assist Metro with developing policy level decisions. The baseline year for the GHG inventory was 2005, and was selected for the following reasons:

- Data used to develop the GHG inventory was readily available. Data from 2007, the most recent "complete" year, would still have data gaps and had significant rain events.
- In 2005, the region did not experience abnormal weather events and was considered to be a fairly typical year for the region in terms of temperature measurements. It is important to note that 2005 did have the ninth driest August and was tied for the first driest October in recorded history. However, this will not affect the GHG inventory in a meaningful way.
- In 2006, the region had several weather anomalies and for this reason was not selected.
- The year 2005 is used by many other cities for GHG inventory development.

The temperature and precipitation chart used for this analysis is attached as **Appendix A**.

The scope of this GHG inventory is for the City of Nashville and Davidson County. Two separate GHG baseline emission inventories were developed: municipal operations and community activities. The municipal operation GHG inventory includes activities that generate GHG emissions from the operation of the municipal government (Metro). The community GHG inventory includes activities within the City of Nashville and Davidson County generated by government, residential, and commercial activities. The municipal GHG inventory is a subset of the community GHG inventory. The primary reason for separating the two inventories was for Metro to understand the GHG emissions resulting from its own operations that it maintains control.

The following is a list of broad GHG inventory assumptions to note as part of this GHG inventory:

- Emissions generated from activities of other municipal governments operating within Davison County but not part of Metro operations, such as Forest Hills, City of Goodlettsville and Berry Hill, were included in the community inventory but not the municipal inventory.
- Onroad fleet data was collected from municipal operations at the airport and are included in the municipal inventory.
- There are four utility districts (Harpeth Valley Utilities District and utilities operated in Goodlettsville, Old Hickory and Ridgetop) within Davidson County that aren't under the specific control of Metro government and are therefore, not included in the municipal inventory, but are included in the community inventory.
- Nashville schools were included in the municipal inventory as a separate sector. The MNPS data is displayed as a subset of the Metro Government data so that varying reduction efforts can be tracked both independently and as a total.
- Offroad equipment emissions, such as trains, construction equipment, and aircraft were not included in the community GHG inventory. Metro offroad

equipment emissions were included as a part of the total gasoline and diesel fuel use.

- GHG emissions associated with land use changes were not included in either GHG inventory. While this could be significant, estimations of GHG from these activities are difficult and beyond the scope of the Clean Air and Climate Protection (CACP) software.

Data needed to complete the GHG inventory was collected by the Metro Health Department. The data collected was received from both internal and external sources to the Metro Government. Data sources are cited in this report under Data Collection and Reporting, below. The data used to develop the municipal and community inventories is assumed to be correct and was not validated independently by the Health Department. This GHG inventory is intended to be used as a policy planning tool and it is expected the GHG inventory will be updated and improved by Metro in the future.

Software

The ICLEI CACP software provided to Metro under its membership with ICLEI was used to develop the baseline GHG inventory. The software was developed in partnership with the State and Territorial Air Pollution Program Administrators (STAPPA), the Association of Local Air Pollution Control Officials (ALAPCO), and Torrie Smith Associates. The software was specifically created to help local governments create greenhouse gas inventories, quantify the benefits of reduction measures, and formulate local climate action plans. The software has been utilized by over 200 cities and counties in the United States to quantify the reduction in GHG emissions. Some of these entities are also signatory's to the United States Mayor's Climate Protection Agreement.

The software contains thousands of emission factors that are used to calculate emissions based on fuel and energy use data, or information on waste disposal. Data was entered into the program through available collected information and no changes were made to the default settings of the software. This software tool produces a high level GHG inventory to be used for the purpose of policy planning.

Data Collection and Reporting

The Health Department staff of Metro collected the required data for development of the baseline GHG inventory. Metro utilized ICLEI Community Analysis Data Collection forms and Government Analysis Data Collection forms to facilitate obtaining available information. Metro staff reviewed and analyzed the collected data and performed data entry into the CACP software. Metro staff was also responsible for ensuring data entry values were in correct units of measure needed for analyses. However, Metro staff did not perform an independent validation of the data and assumed the data provided was correct. Data sources are listed below:

- Electricity data – Nashville Electric Service
- Natural gas data – Piedmont Natural Gas
- Employee Commute data – Internal Survey conducted for the purposes of this GHG inventory in December 2008 (attached as **Appendix B**)
- Metro Vehicle data - Fleet data was collected from four different sources:

- Water/Sewage data – Metro Water Services
- Waste data – Metro Public Works
- Transportation data – Tennessee Department of Transportation and Clean Cities
- Residential, Commercial, and Industrial coal, fuel oil, natural gas, and fuelwood was received by Metro's Regulated Pollutant Emission Inventory
- Davidson County closed landfills – Metro Public Works

To facilitate entry of data into the CACP software, collected data had to be converted and/or interpreted. The following summarizes the processes used:

- The Employee Commute data survey conducted in December 2008 had a 22.1% response rate. This was deemed to be a higher than average response rate for this type of survey. The data was extrapolated for all Metro employees (11,146 in 2005). Additionally, while the survey was conducted in 2008 for current Employee Commute Data, it is assumed that any differences between 2005 and 2008 would be minimal.
- The Vehicle data provided was an inventory of vehicles by vehicle type owned by Metro in 2005. However, the fuel data was provided in terms of total gallons per year for each fuel type utilized by Metro. Therefore, the vehicle inventory and types were used to categorize the vehicles to match the CACP software inputs, and the percentage of the total fleet for each category was used to calculate the gallons per year for each vehicle type.
- Waste data provided by Metro Public Works was total tons disposed of by various operations within Metro. However, a breakdown of waste by type was not provided, (such as paper, construction debris, etc.) therefore the ICLEI defaults were used to calculate the number of tons by type disposed of at a managed landfill.

The software output includes tables, presented in **Appendix C**. The following sections provide a summary of the collected information based on the output from the CACP software. The information is reported in terms of equivalent CO_2 units (CO_2e). Converting all emissions to CO_2e allows for consideration of differences in the Global Warming Potential of each GHG.

Baseline Municipal Emissions

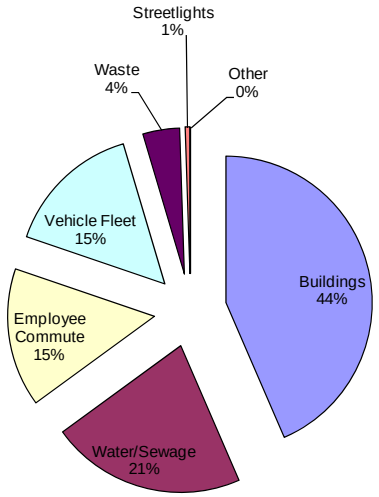
The following information presents the results of the municipal GHG inventory for all Metro operations. This inventory includes MNPS however, availability of fleet data was limited to school buses. Any other fleet vehicles operated by MNPS were not included as the data was not readily available. It is not expected this would account for a large percentage of emissions in this inventory. This data should be collected, if feasible, and included in future inventories. **Table 2** presents the sources of emissions from Metro operations with the associated CO_2e in tons and as a percentage of the total, as well as the energy consumed in kWh. **Figure 4** presents the distribution percentage of CO_2e and energy consumed for each source.

Table 2
2005 Municipal Greenhouse Gas Emissions

Potential Sources	Equivalent CO_2 (tons)	Equivalent CO_2 (%)	Energy (kWh)
Buildings	282,435	43.5	625,663,353
Vehicle Fleet	98,540	15.2	338,073,733
Employee Commute	99,228	15.3	342,227,296
Streetlights	3,306	0.5	4,509,662
Water/Sewage	139,403	21.5	206,433,498
Waste	26,456	4.1	
Other	48	0.0	
Total	**649,417**	**100.0**	**1,516,907,542**

Source: CACP Model

Figure 4
2005 Municipal Greenhouse Gas Emissions by Sector



Overall, Metro's municipal operations generated 649,417 tons of CO_2e. Energy consumption totaled 1,516,907,542 kWh. Results from other local government GHG emission inventories typically fall between 1 and 5 percent of the total community

emissions and the results of the analyses identified Metro operations contribute to approximately within that range, approximately 3 percent of the total CO_2e emissions.

Metro buildings accounted for the greatest CO_2e emissions and energy use in 2005, including 43.5% of the total emissions and 41.2% of the total energy consumed. Metro buildings include all buildings operated by Metro such as City Hall, fire stations, schools, and libraries. Approximately 32.6% of the emissions were generated from electricity and 11% from natural gas. Natural gas contributed to the greatest energy consumption from this source with 337,462,457 kWh.

Water/sewage contributed to the second greatest CO_2e emissions in 2005, but was the fourth greatest energy consumer. Water/sewage includes energy use from activities such as the pumping of water and treatment of wastewater. Electricity and natural gas contributed to 135,622 and 3,781 tons, respectively of the CO_2e emissions. Green electricity was utilized for this sector, which did not contribute to CO_2e emissions.

Metro's employee commute and operation of Metro's vehicle fleet, which ranges from operation of police squad cars to school buses, were the third and fourth largest contributors to emissions in 2005, with 15.3% and 15.2% of the total number of municipal emissions, respectively. These sources were also the second and third greatest energy consumers. Approximately 8.0% of the total vehicle fleet emissions were generated from NES vehicles. Diesel vehicles contributed to the majority of these emissions. Emissions from the Metro vehicle fleet were primarily from gasoline-powered vehicles. A small portion of the emissions were also from the airport vehicle fleet, which consists of gasoline and diesel-powered vehicles.

The waste sector contributed to 4.1% of the total municipal CO_2e emissions generated in 2005. This sector produced negative emissions from plant debris and wood/textiles decomposition in a managed landfill. This is due to the fact that that these types of wastes absorb CO_2 from the atmosphere, and when placed in the landfill the waste materials continue to sequester the carbon. Therefore, the emissions associated with waste disposal were primarily a result of paper product and food waste decomposition from frontloader collection activities, general services, Metro Parks, the Metro Surplus Warehouse, MNPS, Public Works streets and roads activities, and the Sweeping Corporation of America.

The streetlight sector accounted for a small amount of CO_2e emissions in 2005 with 3,306 tons of CO_2e emitted. This sector only included the ambient lighting in Metro, and did not include traffic lights. The emissions were a result of 4,509,662 kWh of electricity use. A negligible amount of emissions (i.e., less than 1%) resulted from NES sulphur hexafluoride circuit breakers.

Metro compared the results of the municipal GHG inventory with other cities of similar population and scope of municipal operations. These results are comparable and there are no anomalies to note.

Metro Nashville Public Schools

The municipal GHG inventory included data from Metro Nashville Public Schools (MNPS). **Table 3** presents a comparison of total municipal versus MNPS GHG data. The following is a discussion of GHG emissions, specifically from MNPS facilities.

MNPS data was identified for the building, vehicle fleet, employee commute, and waste sectors. MNPS operations generated a total of 239,317 tons of CO_2e, which accounts for 36.9% of the total municipal emissions. Energy consumption totaled 541,613,076 kWh,

which is 35.7% of the total municipal energy consumption. Total MNPS operations contributed to approximately 2.0% of the total CO_2e emissions.

MNPS buildings accounted for the greatest CO_2e emissions and energy use for their operations in 2005. A majority of the building emissions were generated from electricity (85% of MNPS building emissions). The remaining building emissions were generated from natural gas. Energy consumption from electricity and natural gas use contributed almost equally for buildings.

Metro's employee commute and operation of the MNPS vehicle fleet were the third and fourth largest contributors to municipal emissions in 2005, with 9.0% and 1.9% of the total number of municipal emissions, respectively. These sources were also the second and third greatest energy consumers. Emissions from employee commute were primarily from gasoline-powered vehicles. The total vehicle fleet emissions were generated from diesel busses.

The waste sector contributed to 1.5% of the total municipal CO_2e emissions generated in 2005. This sector produced negative emissions from plant debris and wood/textiles decomposition. The emissions associated with waste disposal were primarily a result of paper product and food waste decomposition.

Table 3
2005 Municipal and MNPS Greenhouse Gas Emissions

Potential Sources	Equivalent CO_2 (tons)		Equivalent CO_2 (%)		Energy (kWh)	
	MNPS	**Metro**	**MNPS**	**Metro**	**MNPS**	**Metro**
Buildings	158,799	282,435	24.5	43.5	297,814,984	625,663,353
Vehicle Fleet	12,276	98,540	1.9	15.2	41,469,308	338,073,733
Employee Commute	58,656	99,228	9.0	15.3	202,328,784	342,227,296
Streetlights		3,306		0.5		4,509,662
Water/Sewage		139,403		21.5		206,433,498
Waste	9,586	26,456	1.5	4.1		
Other		48		0.0		
Total	**239,317**	**649,417**	**36.9**	**100.0**	**541,613,076**	**1,516,907,542**

Source: CACP Model

Baseline Community Emissions

The following information presents the results of the community GHG inventory. As presented in **Table 4**, in the base year 2005, Metro's community operations generated approximately 14,409,731 tons of CO_2e and a total energy use of 32,166,477,027 kWh.

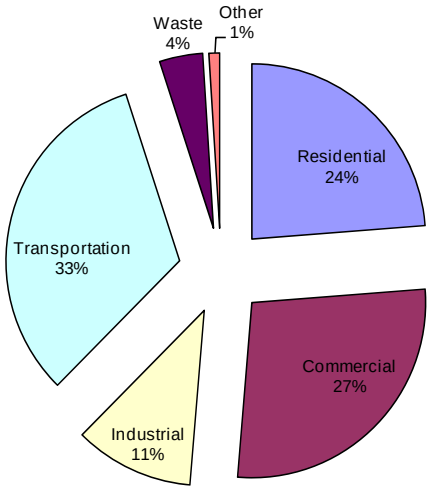
Figure 5 presents the distribution percentage of CO_2e and energy for each sector. These operations include the residential, commercial, industrial, transportation, and waste sectors.

Table 4
2005 Community Greenhouse Gas Emissions

Potential Sources	Equivalent CO_2 (tons)	Equivalent CO_2 (%)	Energy (kWh)
Residential	3,425,508	23.8	6,494,326,185
Commercial	3,969,299	27.5	6,726,112,318
Industrial	1,599,171	11.1	2,876,702,824
Transportation	4,692,856	32.6	16,069,335,700
Waste	580,141	4.0	0
Other	142,756	1.0	0
Total	**14,409,731**	**100.0**	**32,166,477,027**

Source: CACP Model

Figure 5
2005 Community Greenhouse Gas Emissions by Sector



The largest source of CO_2e emissions in the community GHG inventory was from energy consumption (62.4%). This was primarily due to the use of electricity in the commercial (27.5) and residential (23.8%) sectors, but also included the consumption of natural gas, coal, light fuel oil, propane and fuelwood. The transportation sector accounted for the

second greatest CO_2e emissions (32.6%) and the largest amount of energy use in 2005 (50%). This category contains the total number of vehicle miles traveled in the boundaries of Davidson County, but does not include construction equipment activity and other offroad sources such as trains and aircraft. Approximately 27.4% of the emissions were primarily generated from gasoline-powered vehicles. Diesel vehicles; diesel and gasoline-powered school and transit busses; and biodiesel (B-20) and ethanol-powered (E-85) vehicles contributed to a small portion of these emissions (i.e., each less than 5% of the total transportation emissions).

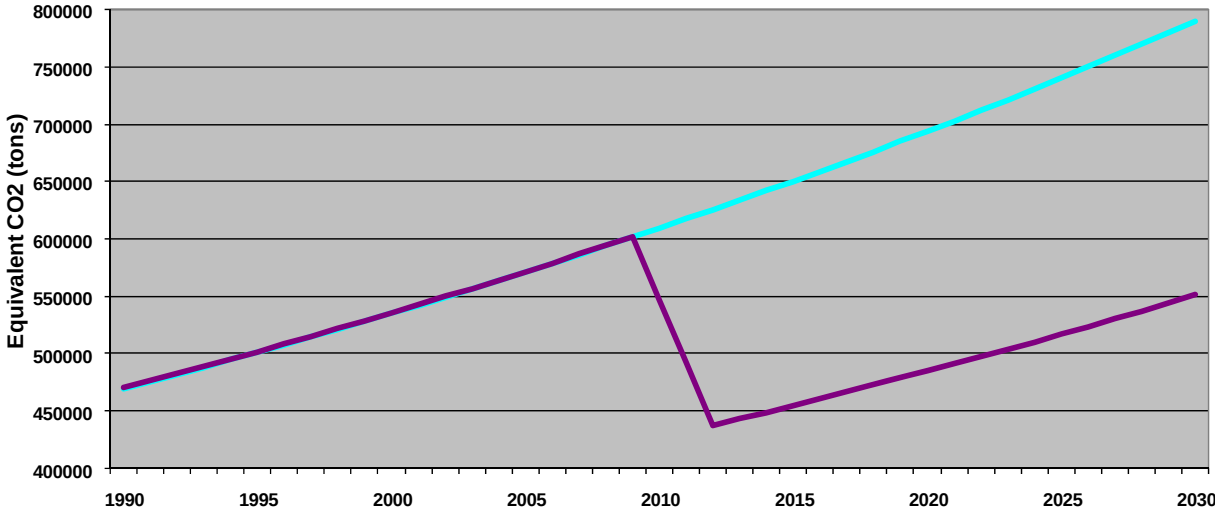
The waste sector accounted for the least amount of CO_2e emissions in 2005 with 580,141 tons of CO_2e emitted. This sector produced negative emissions from compost facilities, and from plant debris and wood/textiles in a managed landfill due to sequestration of carbon described above. Approximately 3.2% and 1.0% of the emissions were a result of paper product and food waste decomposition, respectively. Additionally, CO_2e were estimated for existing but closed landfills in Davidson County with estimates for methane recovery at Bordeaux. These emissions account for 1.0% of the total community GHG inventory.

Backcast/Forecast

The data collected for the 2005 GHG inventory was used to backcast levels of CO_2e to 1990 levels. Backcasting to 1990 is part of the United States Mayor's Climate Change Agreement. **Figure 6** presents the backcast of GHG emissions based on municipal operations. The data identifies municipal GHG emissions accounted for approximately 460,000 tons of CO_2e in 1990. The average percent change in GHG emissions was estimated at 1.3%.[1]

Figure 6 also shows a forecast of municipal GHG emissions to 2020. The light blue line demonstrates the forecast where growth and associated CO_2e emissions continue at the estimated rate of 1.3%. The purple line represents adherence to the United States Mayor's Climate Change Agreement over the next several years (7% below 1990 levels by 2012) and then growth at the estimated rate of 1.3%.

Figure 6
Backcast of Municipal Gas Emissions



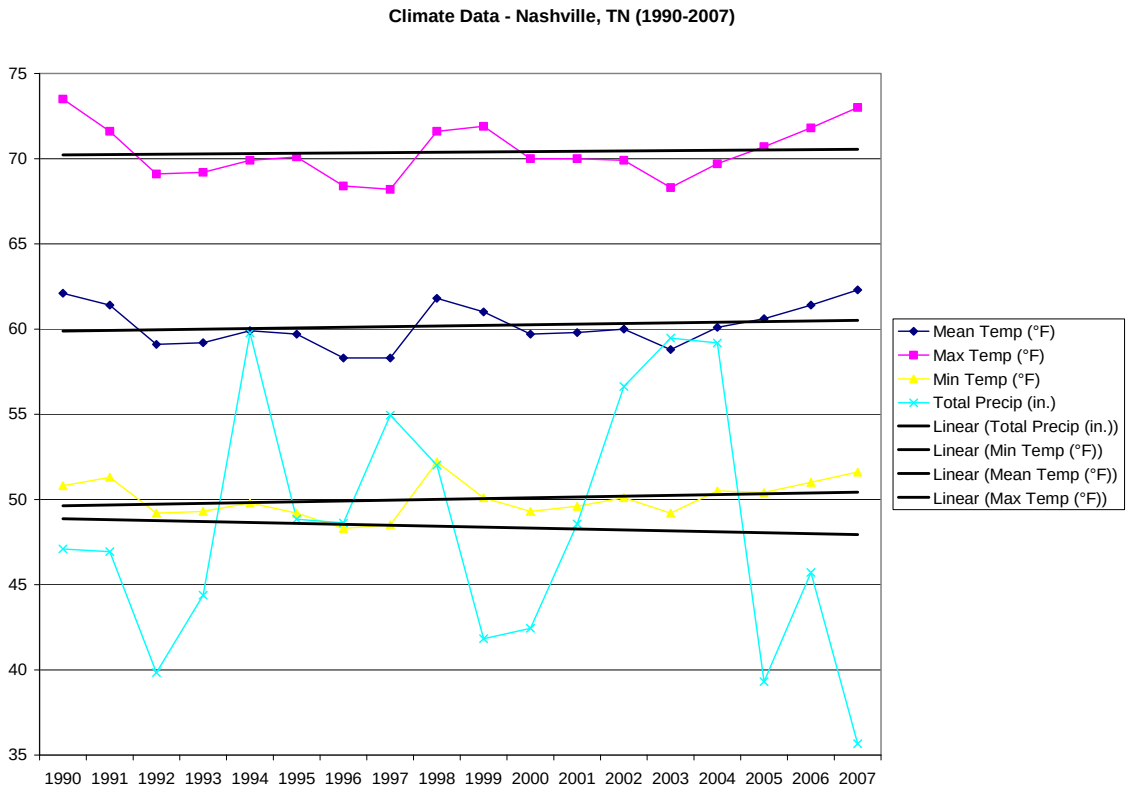
Summary

This baseline GHG emissions inventory represents the profile of community and municipal GHGs that Metro emits in the base year of 2005. The inventory also serves to inform Metro of the major sources of GHG emissions from its operations.

As with many cities, the largest source of GHG emissions from both the community and municipal inventory are from consumption of electricity, followed closed by transportations emissions. Other sources of GHG emissions to consider include consumption of natural gas, employee commute, and waste disposal. This inventory was developed utilizing the ICLEI software CACP and should be updated as deemed necessary by Metro.

Appendix A

Temperature and Precipitation Data



Appendix B

Employee Survey

Metro Employee Transportation Survey	
What Metro Department do you work for?	
Answer Options	**Response Count**
	4973
answered question	**4973**
skipped question	**0**

Number	Department	# of Responses
	Agricultural Extension Service	1
	Assessor of Property	27
	Career Advancement Center	28
	CENTRAL RECORDS	2
	Codes Administration	38
	Convention Center	26
	Council/Council Office	10
	County Clerk	31
	Courts	170
	DA's Office	42
	Election Commission	14
	Emergency Communication Center	39
	Farmers Market	2
	Federal Programs and Grants	6
	Finance	68
	Fire Department	64
	General Services	73
	Health Department	191
	Historical Commission	3
	Human Relations Commission	1
	Human Resources	34
	Internal Audit	4
	ITS	58
	Justice Integration Services	14
	Juvenile Court	49
	Legal	22
	Library	138
	Mayor's Office	9
	Metro Achives	1
	Metro Action Commission	34
	Metro Arts Commission	1

Other - Billing	
Other - EVENT SERVICES	
Other - SSD	
Other - VOC.	
Other - Customer Service Center	
Other - Psychology	
Other - n/a	
Total Other	

MNPS	2508
MTA	28
Municipal Auditorium	3
Office of Emergency Management	8
Other	47
Parks and Recreation	98
Planning Commission	36
Police Department	404
Public Defender	23
Public Works	53
Register of Deeds	12
Sheriff's Office	266
Social Services	30
Soil & Water Conservation	1
Tax Assessor	5
Tennessee State Fairgrounds	3
Transportation Licensing Commission	10
Trustee's Office	10
UT/4-H Extension Service	1
Water Services	226
Youth Services	1
Total	**4973**

Metro Employee Transportation Survey

On average, how many days/week do you work?

Answer Options	Response Percent	Response Count
5	95.3%	4738
4	2.9%	145
3	1.4%	68
2	0.3%	15
1	0.1%	5
	answered question	**4971**
	skipped question	**2**

Metro Employee Transportation Survey		
How do you typically commute to work?		
Answer Options	**Response Percent**	**Response Count**
Bike/Walk	0.5%	24
Bus	1.8%	90
Carpool	4.6%	229
Drive	92.8%	4616
Train	0.3%	14
	answered question	**4973**
	skipped question	**0**

Metro Employee Transportation Survey		
If you use bus, how many days per week on average?		
Answer Options	**Response Percent**	**Response Count**
1	25.2%	54
2	15.0%	32
3	17.8%	38
4	12.6%	27
5	29.4%	63
	answered question	**214**
	skipped question	**4759**

Metro Employee Transportation Survey			
If you drive, what type of vehicle do you drive?			
Answer Options	**Response Percent**	**Response Count**	
N/A - I do not drive to work	1.1%	56	
Auto – Full Size	14.7%	730	14.8%
Auto – Mid Size	30.4%	1514	30.8%
Auto – Subcompact/Compact	19.5%	969	19.7%
Heavy Truck	1.0%	48	1.0%
Light Truck/SUV/Pickup	29.6%	1473	30.0%
Motorcycle	0.3%	13	0.3%
Passenger Vehicle	3.0%	147	3.0%
Vanpool Van	0.5%	23	0.5%
	answered question	**4973**	4917
	skipped question	**0**	

Metro Employee Transportation Survey			
What type of fuel do you use?			
Answer Options	**Response Percent**	**Response Count**	
N/A - I do not drive to work	1.1%	55	
Gasoline	96.1%	4781	97.2%
Diesel	0.6%	28	0.6%
Biodiesel (B-20)	0.0%	1	0.0%
Other biodiesel blend	0.0%	1	0.0%
CNG	0.0%	0	0.0%
Diesel (ULSD)	0.0%	0	0.0%
Electricity	0.1%	4	0.1%
Ethanol (E-10)	1.3%	65	1.3%
Ethanol (E-85)	0.7%	34	0.7%
Ethanol-Diesel	0.1%	3	0.1%
LPG	0.0%	1	0.0%
Methanol (M-85)	0.0%	0	0.0%
	answered question	**4973**	4918

skipped question	**0**

Metro Employee Transportation Survey

Approximately how many miles do you commute round trip per day?

Answer Options	Response Percent	Response Count
0-5	8.0%	399
6-10	13.1%	651
11-15	12.5%	622
16-20	13.1%	653
21-25	10.1%	500
26-30	10.5%	524
31-35	6.6%	329
36-40	6.9%	345
41-45	4.2%	209
46-50	3.6%	181
51-55	2.1%	106
56	9.1%	454
answered question		**4973**
skipped question		**0**

Appendix C

CACP Software Output

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nashville

Government Greenhouse Gas Emissions in 2005

Summary Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)	Cost ($)
Buildings	282,435	43.5	625,663,353	0
Vehicle Fleet	98,540	15.2	338,073,733	0
Employee Commute	99,228	15.3	342,227,296	
Streetlights	3,306	0.5	4,509,662	0
Water/Sewage	139,403	21.5	206,433,498	0
Waste	26,456	4.1		0
Other	48	0.0		
Total	649,417	100.0	1,516,907,542	0

This report has been generated for nashville, tn using STAPPA/ALAPCO and ICLEI's Clean Air and Climate Protection Software developed by Tomie Smith Associates Inc.

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Government Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)	Cost ($)
Buildings				
nashville, tn				
Metro Buildings				
Electricity	76,514	11.8	104,371,438	0
Natural Gas	47,123	7.3	223,476,931	0
Subtotal Metro Buildings	123,636	19.0	327,848,369	0
MNPS				
Electricity	134,764	20.8	183,829,458	0
Natural Gas	24,035	3.7	113,985,526	0
Subtotal MNPS	158,799	24.5	297,814,984	0
Subtotal Buildings	282,435	43.5	625,663,353	0
Vehicle Fleet				
nashville, tn				
Metro Vehicle Fleet				
Gasoline	21,926	3.4	75,465,185	0
Diesel	11,458	1.8	38,624,028	0
Subtotal Metro Vehicle Fleet	33,384	5.1	114,089,213	0
MNAA Vehicle Fleet				
Gasoline	741	0.1	2,545,676	0
Diesel	56	0.0	188,761	0
Subtotal MNAA Vehicle Fleet	797	0.1	2,734,437	0
MNPS Buses				
Diesel	12,276	1.9	41,469,308	0
Subtotal MNPS Buses	12,276	1.9	41,469,308	0
NES Vehicle Fleet				
Gasoline	16,780	2.6	57,628,229	0

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Government Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)	Cost ($)
Diesel (ULSD)	35,126	5.4	118,351,866	0
Ethanol (E-85)	178	0.0	3,800,681	0
Subtotal NES Vehicle Fleet	52,084	8.0	179,780,776	0
Subtotal Vehicle Fleet	98,540	15.2	338,073,733	0
Employee Commute				
nashville, tn				
Metro Employees				
Gasoline	39,740	6.1	136,206,389	
Diesel	208	0.0	699,115	
Biodiesel (B-20)	6	0.0	24,396	
Biodiesel (B100)	0	0.0	24,396	
Ethanol (E-10)	487	0.1	1,848,200	
Ethanol (E-85)	43	0.0	871,104	
Ethanol-Diesel	38	0.0	139,752	
LPG	6	0.0	25,588	
Electricity	44	0.0	59,571	
Subtotal Metro Employees	40,572	6.2	139,898,511	
MNPS Employees				
Gasoline	57,487	8.9	197,035,603	
Diesel	301	0.0	1,011,323	
Biodiesel (B-20)	8	0.0	35,324	
Biodiesel (B100)	0	0.0	35,324	
Ethanol (E-10)	705	0.1	2,673,579	
Ethanol (E-85)	61	0.0	1,260,135	
Ethanol-Diesel	56	0.0	202,199	
LPG	9	0.0	37,047	
Electricity	28	0.0	38,249	
Subtotal MNPS Employees	58,656	9.0	202,328,784	
Subtotal Employee Commute	99,228	15.3	342,227,296	

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Government Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)	Cost ($)
Streetlights				
nashville, tn				
Metro				
Electricity	3,306	0.5	4,509,662	0
Subtotal Metro	3,306	0.5	4,509,662	0
Subtotal Streetlights	3,306	0.5	4,509,662	0
Water/Sewage				
nashville, tn				
Water Sewage				
Electricity	135,622	20.9	185,000,000	0
Natural Gas	3,781	0.6	17,933,498	0
Green Electricity	0	0.0	3,500,000	0
Subtotal Water Sewage	139,403	21.5	206,433,498	0
Subtotal Water/Sewage	139,403	21.5	206,433,498	0
Waste				
nashville, tn				
Frontloader Collection				*Disposal Method - Managed Landfill*
Paper Products	7,852	1.2		0
Food Waste	2,507	0.4		0
Plant Debris	-275	0.0		0
Wood/Textiles	-165	0.0		0
Subtotal Frontloader Collection	9,918	1.5		0
General Services				*Disposal Method - Managed Landfill*
Paper Products	1	0.0		0
Food Waste	0	0.0		0
Plant Debris	0	0.0		0

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Government Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)	Cost ($)
Wood/Textiles	0	0.0		0
Subtotal General Services	2	0.0		0
Metro Parks			*Disposal Method - Managed Landfill*	
Paper Products	193	0.0		0
Food Waste	62	0.0		0
Plant Debris	-7	0.0		0
Wood/Textiles	-4	0.0		0
Subtotal Metro Parks	244	0.0		0
Metro Surplus Warehouse			*Disposal Method - Managed Landfill*	
Paper Products	3	0.0		0
Food Waste	1	0.0		0
Plant Debris	0	0.0		0
Wood/Textiles	0	0.0		0
Subtotal Metro Surplus Warehouse	3	0.0		0
MNPS			*Disposal Method - Managed Landfill*	
Paper Products	7,589	1.2		0
Food Waste	2,423	0.4		0
Plant Debris	-266	0.0		0
Wood/Textiles	-160	0.0		0
Subtotal MNPS	9,586	1.5		0
Public Works Streets & Roads			*Disposal Method - Managed Landfill*	
Paper Products	3,780	0.6		0
Food Waste	1,207	0.2		0
Plant Debris	-133	0.0		0
Wood/Textiles	-80	0.0		0
Subtotal Public Works Streets & Roads	4,775	0.7		0

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Government Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)	Cost ($)
Sweeping Corporation of America				*Disposal Method - Managed Landfill*
Paper Products	1,527	0.2		0
Food Waste	488	0.1		0
Plant Debris	-54	0.0		0
Wood/Textiles	-32	0.0		0
Subtotal Sweeping Corporation of America	1,929	0.3		0
Subtotal Waste	26,456	4.1		0
Other				
nashville, tn				
NES Circuit Breakers				
Sulphur Hexafluoride	48	0.0		
Subtotal NES Circuit Breakers	48	0.0		
Subtotal Other	48	0.0		
Total	649,417	100.0	1,516,907,542	0

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nashville

Community Greenhouse Gas Emissions in 2005

Summary Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)
Residential	3,425,508	23.8	6,494,326,185
Commercial	3,969,299	27.5	6,726,112,318
Industrial	1,599,171	11.1	2,876,702,824
Transportation	4,692,856	32.6	16,069,335,700
Waste	580,141	4.0	
Other	142,756	1.0	
Total	14,409,731	100.0	32,166,477,027

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Community Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)
Residential			
nashville, tn			
Total Residential			
Electricity	2,889,717	20.1	3,941,826,566
Coal	590	0.0	1,593,173
Light Fuel Oil	1,921	0.0	6,807,242
Natural Gas	532,739	3.7	2,526,498,145
Propane	17	0.0	67,861
Fuelwood (Air Dry)	524	0.0	17,532,605
Solar	0	0.0	593
Subtotal Total Residential	3,425,508	23.8	6,494,326,185
Subtotal Residential	3,425,508	23.8	6,494,326,185
Commercial			
nashville, tn			
Total Commercial			
Electricity	3,510,168	24.4	4,788,175,889
Coal	119,560	0.8	322,769,627
Light Fuel Oil	2,607	0.0	9,238,617
Natural Gas	336,964	2.3	1,598,040,885
Green Electricity	0	0.0	7,887,300
Subtotal Total Commercial	3,969,299	27.5	6,726,112,318
Subtotal Commercial	3,969,299	27.5	6,726,112,318

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Community Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)
Industrial			
nashville, tn			
Total Industrial			
Electricity	1,221,635	8.5	1,666,416,149
Coal	296,773	2.1	801,180,062
Light Fuel Oil	904	0.0	3,212,895
Natural Gas	78,914	0.5	374,244,612
Fuelwood (Air Dry)	946	0.0	31,649,105
Subtotal Total Industrial	1,599,171	11.1	2,876,702,824
Subtotal Industrial	1,599,171	11.1	2,876,702,824
Transportation			
nashville, tn			
School Bus			
Gasoline	887	0.0	3,086,390
Diesel	18,138	0.1	61,271,290
Subtotal School Bus	19,025	0.1	64,357,680
Transit Bus			
Gasoline	408	0.0	1,420,086
Diesel	8,346	0.1	28,192,318
Subtotal Transit Bus	8,754	0.1	29,612,404
VMT by Vehicle & Fuel Type			
Gasoline	3,949,441	27.4	13,552,614,602
Diesel	713,839	5.0	2,410,608,594
Biodiesel (B-20)	1,509	0.0	6,359,314
Ethanol (E-85)	288	0.0	5,783,106
Subtotal VMT by Vehicle & Fuel Type	4,665,077	32.4	15,975,365,617
Subtotal Transportation	4,692,856	32.6	16,069,335,700

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Community Greenhouse Gas Emissions in 2005
Detailed Report

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (kWh)
Waste			
nashville, tn			
Compost			*Disposal Method - Compost*
Paper Products	-6,399	0.0	
Food Waste	-2,189	0.0	
Plant Debris	-1,684	0.0	
Wood/Textiles	-674	0.0	
Subtotal Compost	-10,945	-0.1	
Managed Landfill			*Disposal Method - Managed Landfill*
Paper Products	467,943	3.2	
Food Waste	149,414	1.0	
Plant Debris	-16,419	-0.1	
Wood/Textiles	-9,851	-0.1	
Subtotal Managed Landfill	591,086	4.1	
Subtotal Waste	580,141	4.0	
Other			
nashville, tn			
Bordeaux			
Methane	142,756	1.0	
Subtotal Bordeaux	142,756	1.0	
Subtotal Other	142,756	1.0	
Total	14,409,731	100.0	32,166,477,027

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