INVENTORY OF NEW YORK CITY
GREENHOUSE GAS EMISSIONS

April 2007

planYC

Michael R. Bloomberg
Mayor

Mayor's Office of Operations
Office of Long-Term Planning and Sustainability

This report presents the results to date of New York City's participation in ICLEI – Local Governments for Sustainability's Cities for Climate Protection Campaign®. Efforts to quantify New York City's greenhouse gas emissions began in 2002 with an initial assessment of emissions from City government operations. Further research and analyses were conducted in subsequent years, including the completion of 2001 and 2006 government operations inventories and 1995, 2001, and 2005 citywide inventories, the development of emissions forecasts, the quantification of current government emissions reduction measures, and the establishment of emissions reduction targets for both New York City as a whole and for New York City government operations. This report combines these efforts.

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Copies of this report may be downloaded from the New York City Mayor's Office of Long-Term Planning and Sustainability Web site: http://www.nyc.gov/planyc2030.

FOREWORD BY MICHAEL R. BLOOMBERG, MAYOR

In September, I announced that our Administration would complete a comprehensive greenhouse gas inventory for both the city as a whole and for City government operations. I am pleased to now release the results of this important effort. While there is no substitute for federal action, all levels of government have a role to play in confronting climate change and its potential impacts, and this report will help us begin doing that more aggressively.

Because New York City is often a national leader in public policy, and is often seen as the model for the modern city, our municipal government is in a unique position to set the standard for climate change policy initiatives. That is why I created the Mayor's Office of Long-term Planning and Sustainability last year and charged it with developing a comprehensive sustainability plan for the City's future. The result of this effort will be PlaNYC, which will lay the foundation that will allow the City to accommodate an expected increase in population of almost a million people by 2030, and to do so while making the city cleaner, greener, and healthier – which, of course, includes significantly reducing our greenhouse gas emissions. We have set a goal of reducing emissions by 30 percent below 2005 levels by 2030, an ambitious but, we believe, achievable goal.

As this report details, we have stabilized our City government's greenhouse emissions over the last five years due to energy efficiency efforts implemented by the City, despite an increase in electricity use. In addition, our projections indicate that City government emissions will be near today's levels by 2017 because of additional actions that we plan to implement in the near future. While stabilizing our carbon dioxide emissions is an important first step, we still have a great deal of work to do to achieve our long-term target.

This greenhouse gas inventory is a critical first step in reducing our contribution to global carbon dioxide levels. By identifying the largest sources of greenhouse gases, showing trends that may need correction, and showing impacts of actions taken to date, we can design our strategies for achieving our reduction target. Working together with our partners in the public, private, and nonprofit sectors, New York City will do what we do best: lead by example.

Michael R. Bloomberg
Mayor

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EXECUTIVE SUMMARY

Global climate change caused by increasing concentrations of atmospheric carbon dioxide is one of the most significant threats facing our world today.

As a coastal city, New York is particularly susceptible to the effects of global climate change, and the need for understanding the science of climate change and formulating appropriate policy to address scientific findings is intensifying with each passing day. Scientists have said that, over the course of this century, the New York City area will experience the direct effects of global climate change, including increased temperatures, rising sea levels, higher risks of severe floods and storms, and a depletion of crucial natural resources. Climate change is a global problem, but its effects will be very local.

While there are some steps that New York City can take to adapt to warmer temperatures, the greatest urgency is to prevent further climate change by reducing the emission of greenhouse gases. This will need to be a global effort, but New York City can play a significant role. New York City can play three roles in this effort. First, it can and should reduce its greenhouse gas emissions, which are currently as much as those of Ireland or Portugal. Second, it can and should prepare for growth: because the average New Yorker has a greenhouse gas footprint just 29 percent of that of the average American, a growing New York City is itself a greenhouse gas strategy. Third, New York's role as a leader among cities and a media center means that it can, and should, lead by example.

In 2002, New York joined the network of more than 750 municipalities worldwide actively involved in ICLEI's Cities for Climate Protection® (CCP) Campaign. Expanding on this commitment, in 2006 Mayor Bloomberg created the Mayor's Office of Long-term Planning and Sustainability, and charged this office with developing a comprehensive sustainability plan for the City's future. This effort, called PlaNYC, will put forward a strategy to reduce the city's greenhouse gas footprint, while also accommodating a population growth of nearly one million, and improving our infrastructure and environment. Recognizing the importance of doing its part to reduce global carbon emissions, and the value of leading by example, New York has set the goal of reducing its citywide carbon emissions by 30 percent below 2005 levels by 2030.

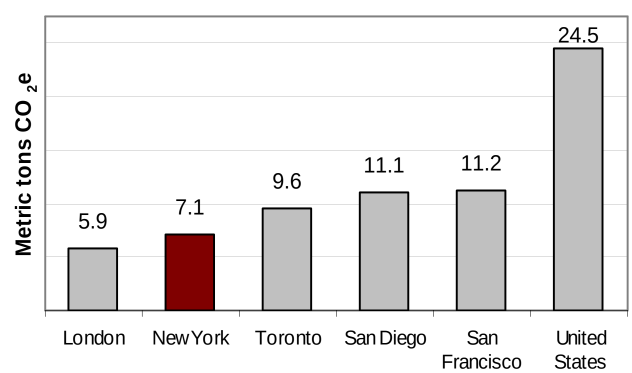


Figure i. Per capita CO_2e emissions of select cities and the United States. Calculations are based on reported greenhouse gas inventories with the understanding that differing methodologies and emissions sources exist.

The greenhouse gas emissions inventory, forecasts, and reduction targets included in this report complete the first and second phases in the CCP Campaign, beginning a process that will continue with the implementation of New York City's carbon reduction plan contained within PlaNYC. Assessing a city's greenhouse gas emissions allows for the identification of the major sources of emissions, demonstrates any trends that exist, and shows the impact of actions taken to date.

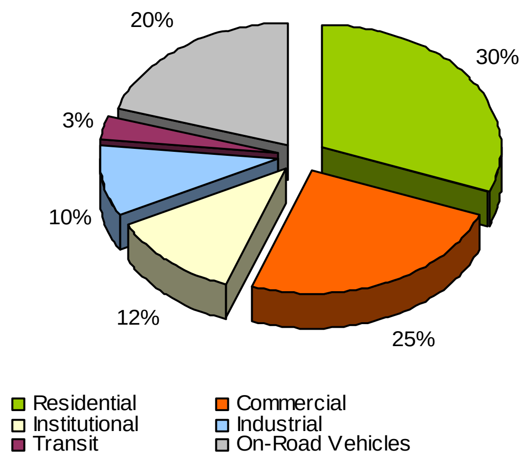


Figure ii. 2005 New York City citywide CO_2e emissions, (58 million metric tons).

This inventory quantifies greenhouse gas emissions that are produced in the city as a whole (citywide inventory) and as a result of New York City government operations (government inventory) in the sectors of building energy use, vehicle fuel consumption, solid waste generation and management, streetlight and traffic signal energy use, transit operations, and water and sewer facility energy use. Emissions from City government operations are a subset of the citywide total. Emissions included in the inventory are both direct emissions (those generated from the combustion of fossil fuels in vehicles or building boilers and emitted from landfills or water pollution control plants), and indirect emissions (generated by the combustion of fossil fuels to generate electricity and/or steam that is used to light, cool, power, and/or heat buildings, streetlights, and industrial facilities). As agriculture is virtually nonexistent in New York City, methane and nitrous oxide emissions from this sector—often significant when measuring emissions in other geographic areas or on a larger scale—are not included.

In 2005, New York City's total greenhouse gas emissions were 58.3 million metric tons of carbon dioxide equivalent (CO_2e).[1] Of these, 79 percent were caused by the consumption of energy by buildings in the City, in contrast to the national average of 34 percent. New York's citywide CO_2e total figures exclude emissions from aviation and marine freight shipping, as these two sources are not routinely included in city emissions inventories. However, because these sources represent significant CO_2e emissions, and because New York serves as a major regional air travel and marine freight hub, emissions from these two sources have been included in this report for reference. From 1995 to 2005, CO_2e emissions increased by a total of 8.5 percent. Figure i shows the distribution of total citywide CO_2e emissions by sector.

Based on observed citywide CO_2e emissions from 2000-2005, compound annual growth rates (CAGR) were calculated for emissions from electricity use (buildings and transit), building heating fuels, and on-road combustion vehicles (including diesel-

[1] All emissions of CO_2e in this report are reported in units of metric tons (one metric ton equals 1.102 short tons)

powered rail transit). From these calculations, a total CAGR of 0.95 percent a year was calculated and used to generate an emissions forecast for 2030. By the 2030 target year, citywide CO_2e emissions are projected to increase by approximately 27 percent in a business-as-usual scenario to approximately 74 million metric tons per year. Figure iii on the right shows this increase.

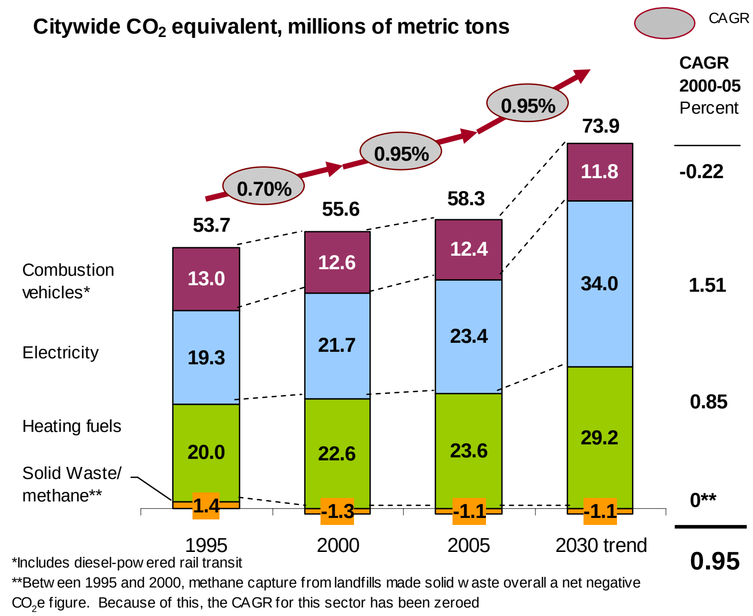
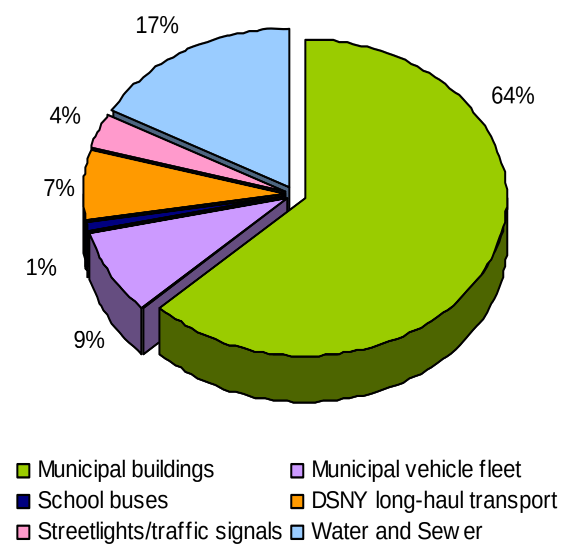


Figure iii. New York City citywide CO_2e emissions, showing compound annual growth rates for combustion vehicles, electricity, and heating fuels. A 0.95 percent CAGR assumes business-as-usual conditions.

In 2006, City government operations resulted in the emission of 3.8 million metric tons of CO_2e. Of these, 64 percent resulted from the operation of City buildings, 17 percent resulted from water and sewer operations, and 9 percent resulted from the operation of City fleet vehicles. New York's government total CO_2e figures exclude emissions from taxis, for-hire vehicles (FHVs), and City employee commuting because these sources are not under the direct control of City government. However, because these sources represent significant CO_2e emissions, and because the City government does have opportunities to influence reductions to these sources, they have been included in this report for reference. Government emissions increased by 15 percent between 1995 and 2001 and remained stable from 2001 to 2006. Figure iv shows FY 2006 City government CO_2e emissions by sector.



Actions the City government have already taken to reduce CO_2e emissions have resulted in the annual avoidance of the emission of 446,000 metric tons of CO_2e. Actions planned to be implemented by 2017 are projected to result in the annual avoidance of 404,000 metric tons of CO_2e. Because of past or planned actions, government emissions remained stable from 2001 to 2006, and are projected to remain stable for the next decade, despite a growth in electricity consumption of approximately two percent annually. This stabilization clearly demonstrates the effectiveness of energy efficiency measures in avoiding carbon emissions, a lesson that supports similar actions across the private sector.

Unless otherwise noted, the citywide inventory base year for data collection is 2005; the government inventory base year for data collection is Fiscal Year 2006 (July 1, 2005 – June 30, 2006). Additional data were also collected and analyzed for past years to assess the City's historic greenhouse gas emissions. Information about ongoing government projects that contribute to reducing greenhouse gas emissions was also gathered to allow the City to assess its progress and to help guide new policy decisions. Data are reported in units of metric tons of carbon dioxide equivalent (CO_2e), a common unit that allows emissions of greenhouse gases of different heat trapping potential to be added together and allows a direct comparison of different greenhouse gases.

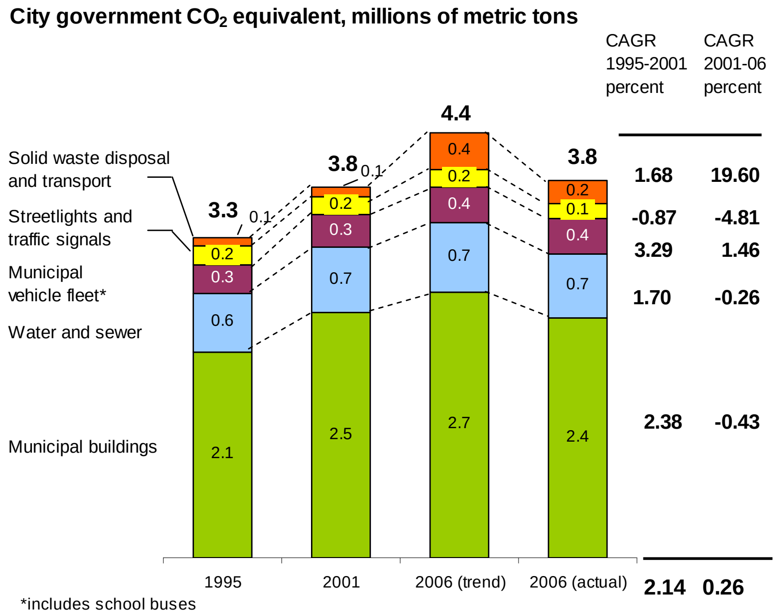


Figure v: New York City government CO_2e, millions of metric tons. Actions taken by the City government have stabilized emissions from 2001 to 2006.

CLIMATE CHANGE AND ITS POTENTIAL IMPACTS

There is broad consensus within the scientific community that human activity is changing the Earth's climate through increasing concentrations of greenhouse gases—primarily carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs)—in the atmosphere.

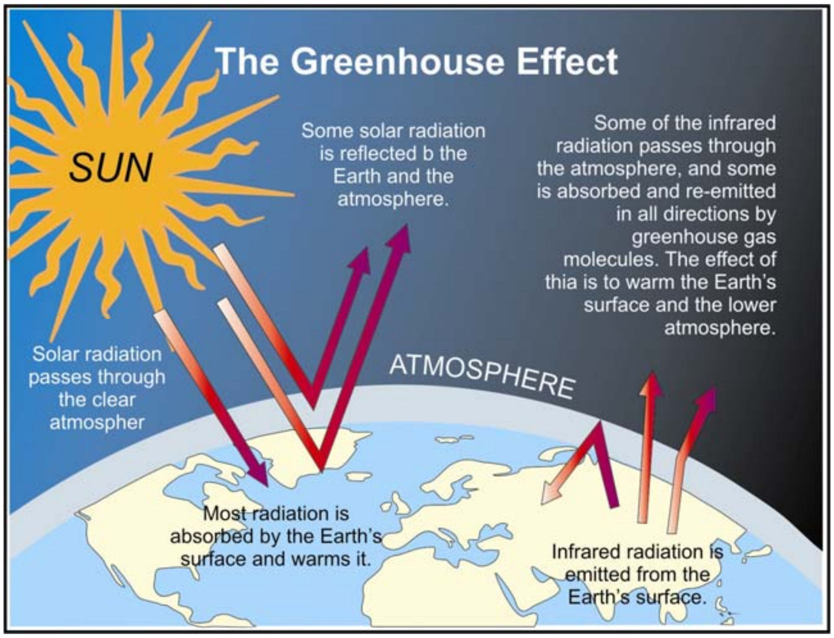


Figure 1. The greenhouse effect. Center for Climate Systems Research and U.S. Office of Science Technology and Policy.

Greenhouse gases are a key element of the earth's atmosphere because they trap energy from the sun, creating a natural "greenhouse effect," as seen above in Figure 1 "Without this effect, temperatures would be much lower than they are now, and life as known today would not be possible."[2]

This natural balance of greenhouse gases in the atmosphere, however, is being disturbed by human activities such as industrial processes, fossil fuel combustion, and changes in land use—actions that release large amounts of certain greenhouse gases into the atmosphere. This increase in greenhouse gas concentration traps additional energy in the lower atmosphere, thus warming it beyond its normal temperature. Industrial activity has contributed to a 30 percent increase in the global CO_2 level since the beginning of the Industrial Revolution through the combustion of fossil fuels for energy.[3] Other anthropogenic contributions of greenhouse gases include the clearing of

[2] United States Environmental Protection Agency. *Climate Change and New York.* 1997. Available from http://yosemite.epa.gov/oar/globalwarming.nsf

[3] Ibid.

forests for development and agriculture, methane production from the decomposition of solid waste, and the manufacturing of chlorofluorocarbons.

The term "global climate change" refers to the destabilizing impact on climate and weather patterns that results from continuous addition of these gases, the resultant increase in heat energy in the earth's atmosphere, and the associated changes that follow. Even small changes in the average temperatures can be accompanied by an increase in severe weather events such as storms and droughts, ecosystem change, loss of animal and plant species, stresses to human health, and alterations in regional agricultural productivity. Figures 2 and 3 illustrate the correlation between increased atmospheric CO_2 concentrations and global average temperature since 1860.

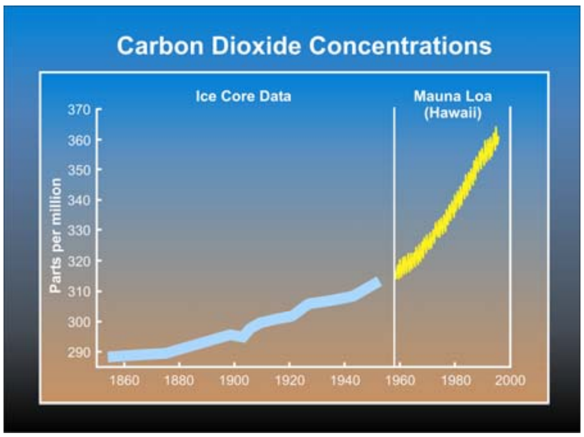


Figure 2. Carbon dioxide concentrations. Center for Climate Systems Research and U.S. Office of Science Technology and Policy. The Mauna Loa Observatory in Hawaii is considered to be the most favorable location in the world for sampling atmospheric CO_2.

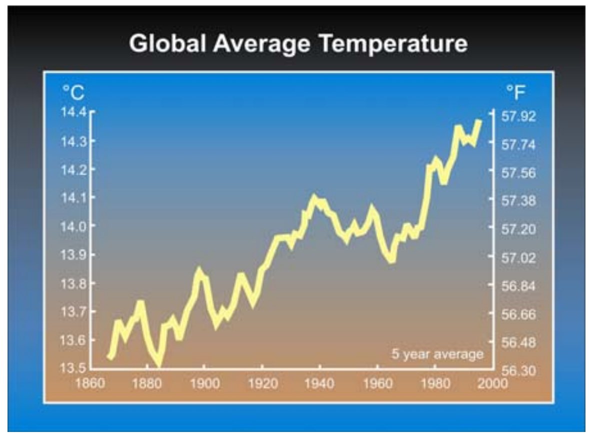


Figure 3. Global average temperature. Center for Climate Systems Research and U.S. Office of Science Technology and Policy.

Although climate change is a global issue, the effects of rapidly rising temperatures will be felt in every local community. Average temperatures in New York State are projected to increase by between 2°F and 8°F by 2100, with the largest increases in the coastal regions such as New York City.[4] Average precipitation is also expected to rise by 10 to 20 percent, with extreme wet and snowy days becoming more frequent.[5] Intense weather trends will be felt on the opposite end of the temperature spectrum, as the occurrence of summer days with temperatures above 90ºF are expected to multiply from 14 days in 1997-1998 to 40-89 days by the 2080s.[6] Climate change will impact

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[4] United States Environmental Protection Agency. *Climate Change and New York.* 1997. Available from http://yosemite.epa.gov/oar/globalwarming.nsf
[5] Ibid.
[6] Rosenzweig, C. and W.D. Solecki (Eds). 2001. Climate Change and a Global City: The Potential Consequences of Climate Variability and Change—Metro East Coast. Report for the U.S. Global Change Research Program, National Assessment of the Potential Consequences of Climate Variability and Change for the United States, Columbia Earth Institute, New York. 224 pp.

human health, coastal areas, water supplies, agriculture, ecosystems, demand for energy, and infrastructure. The potential impacts of climate change to New York City are summarized as follows:

A. Public Health and Air Quality

- Higher temperatures and increased frequency of heat waves may increase the number of heat-related deaths and the incidence of heat-related illnesses, particularly among the elderly and poor.
- Higher temperatures may expand the habitat and infectivity of disease-carrying insects (mosquitoes and ticks), increasing the risk to humans.
- As a heavily populated urban area, New York City is particularly vulnerable to the effects of ground-level ozone, a major precursor to smog. Ozone is produced when higher temperatures and strong sunlight react with hydrocarbons and nitrogen oxides (NO_x), worsening air pollution and potentially exacerbating respiratory illnesses such as asthma.

B. Coastal Areas

- New York City has one of the most urbanized coastlines in the United States, thus making it particularly vulnerable to the rises in sea level that are expected to accompany increases in temperature.
- Along much of the New York coast, sea level could rise significantly: estimates range from 11.8-37.5 inches in the 2080s.[7] Such a rise in sea level can lead to flooding and complete inundation of low-lying areas, loss of coastal wetlands, erosion of beaches, and saltwater intrusion into lakes and rivers, and will likely increase the vulnerability of coastal areas to storms and other severe weather patterns.
- Flooding could become more frequent and severe as the century progresses. According to one estimate, the probability of a “100-year flood” may increase from once in 80 (where it is today) to once in 43 years by the 2020s and up to once in 19 years by the 2050s.[8]
- Low-lying and waterfront infrastructure could experience flooding.[9]

C. Water Supply

- The city’s water system could be affected by increased evaporation of water due to warmer temperatures, which would reduce river flows and lower lake and reservoir levels, particularly in summer when demand for water is at its highest.
- Higher temperatures and more violent storms could lead to increased turbidity of reservoirs.

[7] Rosenzweig, C. and W.D. Solecki (Eds). 2001.
[8] Ibid.
[9] Ibid.

D. Energy Demands

- A warmer climate increases total demand for electricity, because the increase in demand for summer cooling is expected to outweigh the decrease in winter warming needs.
- The urban heat island effect (the absorption of heat by buildings during daylight hours and the radiation of the heat at night) already causes New York City to be warmer than the surrounding area. With a warming climate, the urban heat island effect will become an increasing issue of concern for New York City.

GENERAL METHODOLOGY

This report contains the results of two separate analyses: an inventory of all greenhouse gases emitted in New York City and an inventory of just those emissions resulting from the operations of the New York City government. The government inventory results represent a subset of the larger citywide total.

The purpose of this inventory is to provide City government with information to inform policy decisions. In accordance with the Cities for Climate Protection (CCP) methodology, every attempt was made to ensure that these quantifications were as close to actual emissions as possible and that all uncertainties were reduced as far as practicable.

Clean Air and Climate Protection (CACP) Software

The National Association of Clean Air Agencies (formerly STAPPA and ALAPCO), ICLEI, and Torrie Smith Associates Inc., developed the Clean Air and Climate Protection (CACP) software used by most participants in the CCP Campaign. The software translates data on energy use, transportation patterns, solid waste disposal, and other inputs into greenhouse gas emissions. In addition, the software quantifies the benefit of actions that have the effect of avoiding or reducing CO_2e emissions.

All outputs from the CACP software used in this report are in units of metric tons of carbon dioxide equivalent (CO_2e). CO_2 equivalent is a common unit that allows emissions of greenhouse gases of different strengths to be added together and allows each greenhouse gas to be weighted according to its relative contribution to global climate change. For example, methane and nitrous oxide are much less abundant than carbon dioxide in the atmosphere, but because they have a greater potential to impact global climate change, conversion into CO_2e accords them much more weight than their abundance may suggest.

CITYWIDE INVENTORY METHODOLOGY

1. General Overview of the Citywide Emissions Inventory

The greenhouse gas emissions inventory included in this section of the report documents CO_2e emissions resulting from New York City in 1995, 2000, and 2005. The inventory accounts for energy used and solid waste generated within the city. Therefore, emissions resulting from electricity used in New York City but produced elsewhere, as well as the decomposition of waste generated in New York City but disposed of at a landfill somewhere else, are counted as resulting from New York City. The New York City citywide inventory consists of the following sectors:

Residential: electricity, natural gas, fuel oil, and steam consumption in residential buildings in New York City.
Commercial: electricity, natural gas, fuel oil, and steam consumption in commercial facilities in New York City.
Institutional: electricity, natural gas, fuel oil, and steam consumption in large institutional and governmental facilities in New York City.
Industrial: electricity, natural gas, fuel oil, and steam consumption in New York City's industries.
Transportation: gasoline and diesel fuel used by on-road vehicles in New York City as well as diesel and electricity used in New York City's transit system.
Waste: amount and composition of waste generated by residents, businesses, and by the construction and demolition sector.
Aviation: fuel used by planes leaving from LaGuardia and John F. Kennedy International airports.
Water Freight: fuel used to ship freight by water to or from New York City.

It is important to note that, to date, the data contained within this report have not been validated by an independent consultant. The primary purpose of the information contained herein is to develop trend analyses for the purposes of guiding climate change policy decisions. This is not a tool adequate for developing regulation, and care should be exercised in comparing the results of this inventory to those done by other communities.

2. Base Year and Background Analysis Years

The base year, 2005, was chosen to align with the larger framework of PlaNYC. This represents a deviation from the typical method employed in the Cities for Climate Protection Program, which is to establish a base year as far into the past for which reliable data can be obtained. While consistency with the City's larger planning process was deemed a higher priority, it was accepted that trend analysis and comparison to historical years was of value. To accommodate both purposes, inventories were also conducted for two background analysis years, 1995 and 2000.

3. Residential, Commercial, Institutional, and Industrial Sectors

Data for these sectors were compiled and analyzed by a consultant to the City, and final refinement was done by New York City Mayor's Office staff with support from ICLEI staff. Original data were gathered from utility companies and sorted into residential small (one to four families), residential large (more than four families), commercial, institutional, and industrial sectors. In all cases except heating oil, the aggregate data were provided based on metered amount delivered. Therefore, there is a high level of confidence in accuracy of the totals. Data were mapped to the various building types based on billing rate schedules. Where a rate schedule could apply to more than one category, U.S. Census Bureau and New York State Energy Research and Development Authority (NYSERDA) data were used to divide the subtotal among the possible categories. The institutional category is considered to be a subset of the commercial sector. There is a lower level of confidence in the accuracy of the distribution of total energy use than in the metered data provided by the utilities. The aggregate results are believed to be highly accurate.

Data for total electricity use was provided by Con Edison in kilowatt hours (kWh) by rate schedules, sorted by a consultant to the City, and each sector's total was multiplied by the electricity coefficient described in Appendix A.

Data for natural gas use were provided by Con Edison and KeySpan in decatherms by rate schedule, converted to millions of British thermal units (MMBTU) and sorted by a consultant to the City. Each sector's total MMBTU was multiplied by the coefficient embedded in the CACP software. Data were only available from KeySpan for 2005 and 2000. Accordingly, 2000 natural gas use was substituted for the unavailable 1995 data in the 1995 background year inventory.

Data for total steam use were provided by Con Edison in pounds delivered and organized by rate schedule. These totals were converted to MMBTU and sorted by a consultant to the City. Each sector's total was multiplied by the steam coefficient described in Appendix A.

Data for heating oil use were derived from the 2004 Petroleum Infrastructure study done for the New York State Energy Research and Development Authority. Data were provided for the New York City Metropolitan Region. The total for each sector was correspondingly decreased to reflect the proportion of the regional population that lives within the New York City limits. Data were only available to describe one year, 2004. Other years were assumed to be constant in all regards except temperature. Totals were adjusted to reflect the number of heating degree days recorded each year at the Central Park weather station.

4. Transportation

The Transportation sector of the citywide greenhouse gas emissions inventory attempts to quantify the emissions that result from energy used for transportation within New

York City limits. Thus emissions from automobiles which travel from outside of the city are counted from the point where the vehicle enters the city. Emissions from trucks carrying freight and passing through the city have been counted from one side of the city to the other; and emissions from commuter rail are prorated based upon the portion of the trains' emissions that occur while within New York City. It should be noted that this methodology differs significantly from that used in quantifying the emissions from shipping and aviation.

The calculation of on-road vehicle emissions was based on an estimation of vehicle miles traveled (VMT). For 2007, average annual daily miles traveled (AADMT) in four categories (automobile/motorcycle, light trucks, heavy trucks, and buses) were calculated by a New York City Department of Transportation consultant using the New York Metropolitan Transportation Council (NYMTC)'s Best Practice Model (BPM). Growth factors in the BPM were amended by using New York City Department of City Planning land-use projections that more accurately reflect expected impacts of transit-oriented development policies. For 2030, AADMT was also forecast using the same methodology. These data were converted into annual vehicle miles traveled, and the average annual percentage change between 2007 and the 2030 forecast was used to estimate the miles traveled in each of the inventory years.

VMT for each category was entered into the CACP software. The calculation embedded in the software is:

- VMT (miles) x average fuel efficiency of vehicle category (miles per gallon) x CO_2e coefficient for fuel type (pounds per gallon) = pounds of CO_2e

The average fuel efficiency of each vehicle category is based on distribution vehicles within each class based on national trends of actual vehicle use. A table showing the fuel efficiencies embedded in the CACP software is available in Appendix A. The original source for this data was the U.S. Energy Information Administration's *Transportation Energy Databook*.

The Metropolitan Transportation Authority (MTA) New York City Transit reported the total amount of diesel fuel in gallons used in providing bus transit. The corresponding quantity of greenhouse gases in each year was then subtracted from the total for the "buses" category included as part of total on-road VMT as described above. The remainder was ascribed to the category "buses – all other" and represents intracity transportation, tour buses, etc.

Electricity used in operation of the subways was reported by MTA New York City Transit in kWh. Electricity used was separated into traction and non-traction (station lighting, etc.) and was entered separately in the software. The total was subtracted from the institutional electricity total to avoid "double counting."

MTA Long Island Rail Road reported total diesel and electricity used for traction. Electricity provided by the New York Power Authority (NYPA) was considered to be the portion of their electricity used to power trains within New York City. This was subtracted from the institutional electricity used total to avoid “double counting.” Diesel fuel presumed to be used within New York City was determined based on MTA’s estimate that 10 percent of the total system miles traveled are within the city and that a corresponding proportion of the fuel is used as well.

MTA Metro North Rail Road reported total diesel and electricity used. In-city electricity use was determined based on the electricity metered at New York City substations. This was subtracted from the institutional electricity total to avoid “double counting.” Diesel fuel used was based on the proportion of track miles within the city compared to total system track miles.

The Port Authority Trans-Hudson Corporation (PATH) train reported total electricity used system-wide. Of this, 23 percent was presumed to be within New York City limits, as reported by PATH.

5. Solid Waste

The Cities for Climate Protection Campaign supports two alternative methods for calculating emissions generated from the decomposition of solid waste. This inventory uses the waste commitment method which accounts for the total decomposition of solid waste (which may actually take many years) as though it all occurred in the year in which the waste was generated and deposited into landfills. The emissions factors employed by the CACP software are consistent with standards developed by the U.S. Environmental Protection Agency (EPA) and are available for review in Appendix A.

Solid Waste from New York City was considered in four categories:

- New York City Department of Sanitation (DSNY) managed waste, which accounts for the residential waste stream and waste gathered by the City government such as receptacles located on the street or in City parks.
- Commercial putrecible waste, which is waste collected by a large number of private haulers that contains organic material.
- Construction and demolition waste, which is considered because of the significant wood content even though it is traditionally categorized as non-putrecible.
- Clean fill, which is considered to have no impact on the city’s carbon footprint, was not included in the inventory.

For each category of waste it was necessary to know the quantity of the waste as well as the composition of the waste stream. The CACP software, following EPA guidelines, considers two factors:

- Methane – anaerobic decomposition of organic waste produces methane, which, because of its high global warming potential (21 times that of CO_2), is a significant concern. Most managed landfills capture and burn some portion of the methane. In the case of New York City this proportion has changed significantly over the past ten years. In 1995 the recovery rate at Fresh Kills landfill was estimated by DSNY to be 25 percent. By 2000, it was estimated to be 75 percent. After the close of Fresh Kills in 2001, New York City's waste stream was diverted to a large number of smaller regional landfills. Because a precise weighted average methane recovery factor was difficult to acquire, the national average of 75 percent methane recovery was applied to the 2005 waste stream as well.

- Landfill sequestration – A portion of waste disposed in landfills is composed of carbon and is not expected to break down, therefore becoming sequestered in the landfill. This is a negative number, which represents carbon dioxide that was absorbed from the atmosphere through respiration during the life of the organic matter and which will not break down in the landfill in the foreseeable future. In cities like New York City (after 2000) where there is a high methane recovery factor, the effect of landfill sequestration results in the net CO_2 generated by solid waste to be a negative number.

Waste stream composition for each of the three categories of waste was determined based on the DSNY 2004-2005 Waste Characterization Study. In each case the relevant consideration was the composition of the waste stream upon reaching the landfill, after the effects of recycling had already been subtracted. Table 1 summarizes the waste share of each sector.

Table 1. Solid waste share for citywide inventory

Waste type	DSNY-managed	Commercial	Construction and demolition
Paper	23%	47.5%	
Food waste	16%	13.8%	
Plant debris	10%	2.9%	
Wood/textiles	12%	6.1%	21.3%
Other (non-organic)	39%	29.8%	78.7%

Total tonnage of waste delivered to the landfill by DSNY was obtained from the City of New York Mayor's Management Reports in each relevant year.[10] Tonnage of commercial putrecible waste and of construction and demolition waste was extracted from the DSNY 2004 Commercial Waste Management Study.[11] Data observed for 2000 were used for both commercial putrecible and construction and demolition waste. 2005 forecasted tonnages were used for both categories. 1995 tonnage was assumed to be equal to the average of 2000-2003.

It should be noted that the version of CACP software used for these analyses does not allow users to enter different landfill methane capture rates for different analyses years.

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[10] Mayor's Management Reports available online at http://www.nyc.gov/html/ops/html/mmr/mmr.shtml.
[11] New York City Department of Sanitation, *Commercial Waste Management Study*, 2004. Available online at http://www.nyc.gov/html/dsny/html/reports/cwms-ces.shtml.

Due to this limitation, and because methane capture rates changed for the different analysis years, the methane capture rate must be changed each time the year is changed in order to obtain accurate results.

In addition to the emissions from waste as a result of the above sources, data for two additional sources of emissions was collected as part of the government inventory: emissions from methane generated by the City's water pollution control plants, and emissions resulting from the interim long-haul export of solid waste to landfills well beyond the city limits. As these emissions sources were not accounted for anywhere else in the citywide inventory, and in order to be consistent with the goal of accounting for all government emissions as a subset of emissions within the citywide inventory, these emissions were added to the solid waste sector of the citywide inventory. Details of the data collection process and methodology for calculating emissions are available in the government inventory section of this report.

6. Aviation

The Cities for Climate Protection Campaign recommended methodology does not typically include emissions from aviation in the city's inventory. This is the case for several reasons: reduction targets under the Kyoto Protocol are not inclusive of the emissions from aviation; individual cites have a somewhat limited set of policy options when attempting to find ways to reduce emissions from aviation; and there is not yet full consensus on the best way to quantify the global warming potential of emissions resulting from aviation. To do the most rigorous analysis possible, and because of New York City's role as a significant hub for air travel, an estimate of the quantity of emissions associated with aviation associated with New York City was quantified. However, to facilitate side-by-side comparison to other inventories, the aviation results have been omitted from the total emissions rate except where otherwise noted.

Greenhouse gas emissions from aviation were estimated based on jet fuel loaded onto planes at New York City's two airports. This information was obtained for both John F. Kennedy (JFK) and LaGuardia International Airports from the Port Authority of New York and New Jersey (PANYNJ). A third airport in Newark, New Jersey is considered to primarily serve New York City, but was not included in New York's CO_2e total because it is geographically outside of the City. The CO_2 coefficient from jet fuel was obtained from the U.S. EPA. No attempt was made to account for the different global warming potential resulting from CO_2 emitted at high altitude, nor was any attempt made to account for the impact of contrails or cirrus cloud formation.

7. Shipping

Cities participating in the Cities for Climate Protection Campaign do not typically include emissions from shipping in their respective inventories. This is because data can be difficult to gather and because the range of measures that a local government can take to reduce emissions from shipping freight is significantly constrained. To do the most rigorous analysis possible, and because of New York City's role as a significant hub for shipping, the City determined that it would be preferable to have an estimate of the quantity of emissions resulting from shipping to and from New York City. However, to facilitate side-by-side comparison to other inventories, the shipping results have been omitted from the total emissions rate except where otherwise noted.

Greenhouse gas emissions from shipping were taken from the study entitled "Estimating Transportation Related Greenhouse Gas Emissions and Energy Use in New York State." The methodology employed in the study confers results which may be less accurate than other sections of this inventory, but is the best data currently available. The study describes the approach as follows, "Domestic water freight tonnage was derived from FHWA's [The Federal Highway Administration] Freight Analysis Framework. Water freight energy use estimates were based on the statewide use of residual and diesel fuel. State fuel use was apportioned based on each county's water freight shipping tonnage"[12]. The study included results for 1990, 2001, 2010, and 2020. The 2001 results were used as a proxy for all years in this inventory.

9. Emissions Forecast

The Clean Air Climate Protection software's forecast tool only has emissions coefficients available through 2020. Because of this limitation and also to align with PlaNYC, a forecast was determined by grouping emissions sources into three categories: combustion vehicles (including diesel transit), electricity (including subway and rail traction), and building heating fuels. Individual compound annual growth rates (CAGR) for the period from 2000-2005 were calculated for each of these sectors, and

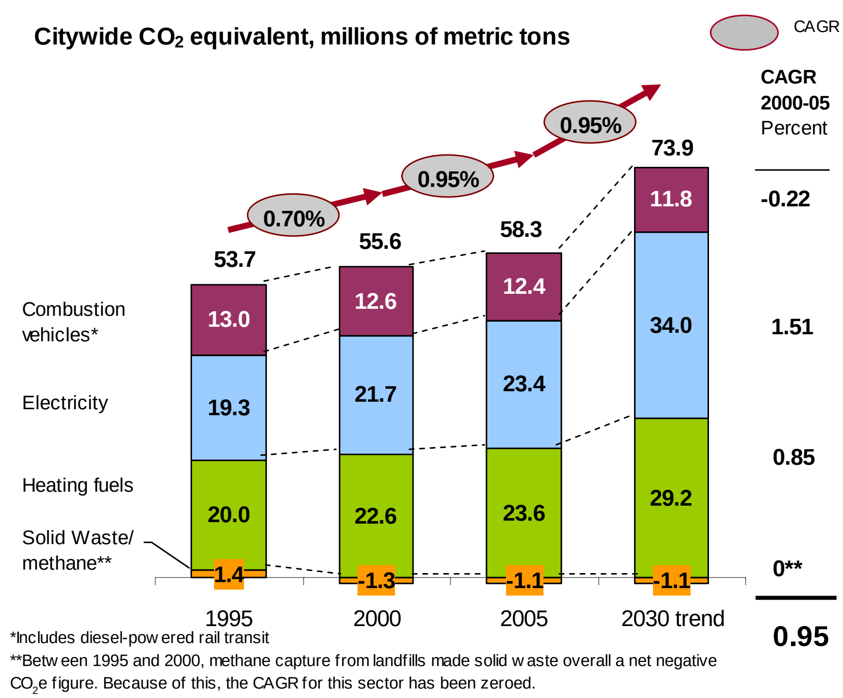

Figure 4. New York City citywide CO_2e emissions, showing compound annual growth rates for combustion vehicles, electricity, and heating fuels. A 0.95 percent CAGR assumes business-as-usual conditions.

[12] *Estimating Transportation Related Greenhouse Gas Emissions and Energy Use in New York State*. ICF Consulting. Completed for New York State Department of Transportation. 2005.

forecasted emissions for each sector were determined. Based on these calculations, and assuming that no new policy decisions would be made, a total business-as-usual CAGR of 0.95 percent was applied to the 2005 observed levels to calculate the 2030 business-as-usual emissions forecast. Between 2005 and 2030 a total growth in CO_2e of 27 percent is projected. Figure 4 above illustrates this forecast.

10. Data Sources

Detailed information regarding all organizations and contacts mentioned in this section can be found in Appendix C of this report. To the furthest extent practicable, quantities, values, and coefficients used in the generation of this inventory have been documented and are organized in Appendix A.

CITYWIDE INVENTORY RESULTS

The operation of New York City's buildings, transportation systems, and vehicles, together with decomposition of solid waste resulted in the net emission of approximately 58.3 million metric tons of greenhouse gases in 2005. The vast majority of these resulted from the operation of New York's buildings, accounting for 79 percent of emissions. Transportation sources, including on-road vehicles and mass transit, account for the remainder of emissions. Due to a 75 percent methane capture rate at landfills receiving New York solid waste, a net negative value was applied from the decomposition of solid waste as a result of carbon sequestration.

To align with the goals of PlaNYC, 2005 was used as the base year for analysis. Data were also collected for 2000 and 1995 background analysis years to demonstrate historic trends. Greenhouse gas emissions, measured in tons of carbon dioxide equivalent (CO_2e), were calculated for the energy used in residential, commercial, institutional, and industrial sectors, as well as in on-road transportation and public transit (subways, buses, and commuter rail). Emissions resulting from the decomposition and transportation of solid waste were also counted. In order to more fully account for the total footprint of New York City, additional data were collected for emissions resulting from air travel and movement of freight by water to and from New York City. ICLEI's Cities for Climate Protection methodology does not specifically require that the emissions inventory of an individual city include all emissions resulting from air travel or freight movement originating in the city due to data complexity, but the City of New York has chosen to represent these numbers separately to the extent possible, for comparative purposes and because of their potential policy relevance.

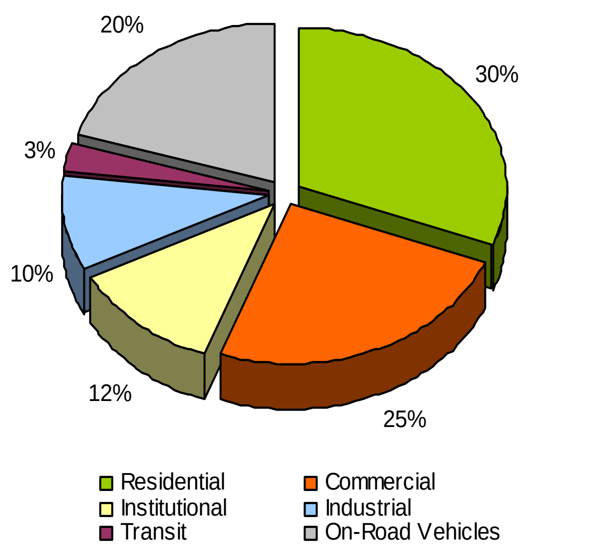

Figure 5. 2005 Citywide CO_2e emissions by sector (58 million metric tons).

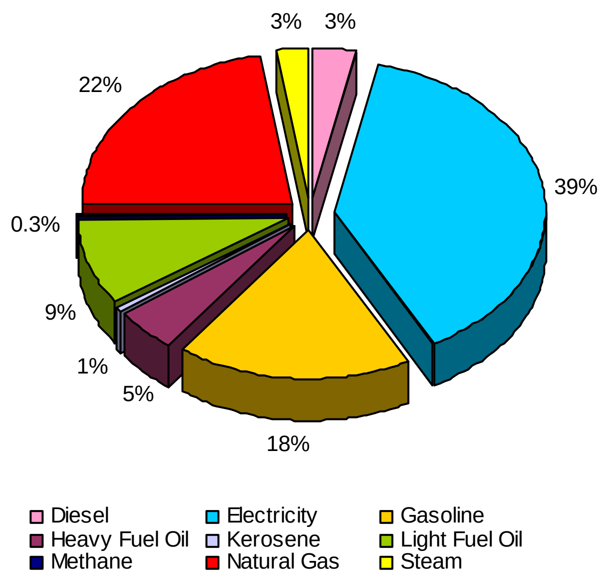

Figure 6. 2005 citywide CO_2e emissions by source (58 million metric tons).

In 2005 the total CO_2e emitted by New York City was 58.3 million metric tons. Figure 5 shows the distribution of these emissions by sector in 2005. Figure 6 shows citywide emissions by source.

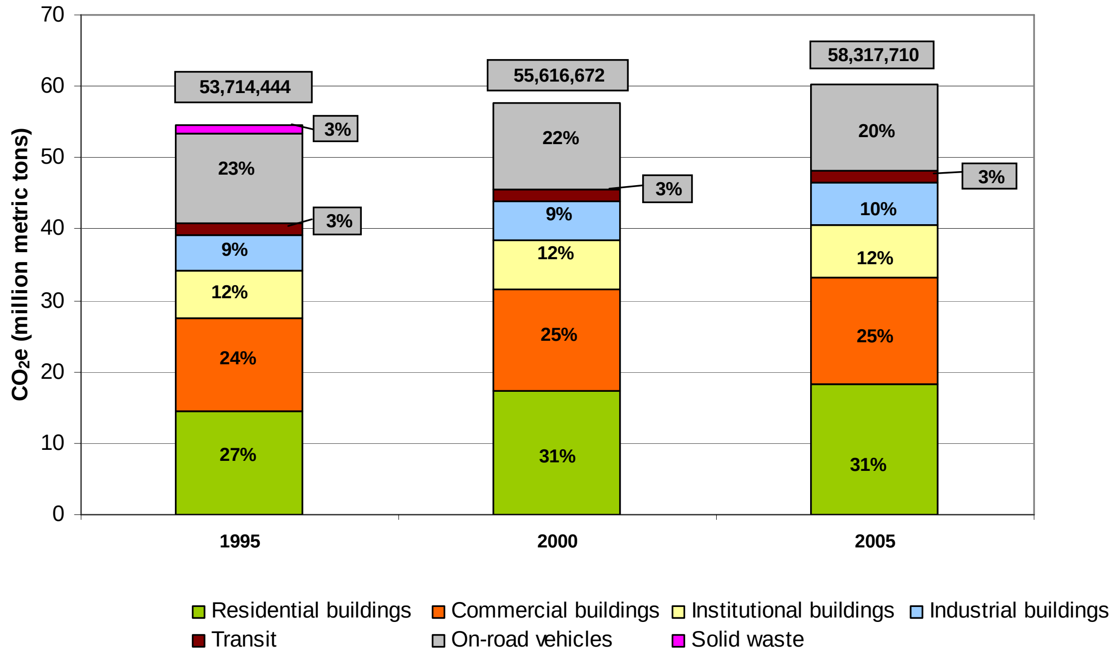

Figure 7. Time Series of New York City's citywide CO_2e emissions by sector, 1995, 2000, 2005.

Figure 7 shows the distribution of emissions in each of the three years inventoried. In most categories the share of the total remains fairly constant over the ten-year period. Perhaps the most significant change is the elimination of emissions from solid waste between 1995 and 2000. This occurred because of an increase in the methane capture rate at Fresh Kills Landfill and continued after the closure of Fresh Kills, because under the City's interim export plan, waste is being sent to landfills outside of the city that are estimated to average a 75 percent methane recovery rate. This methane recovery rate resulted in negative CO_2e emissions in 2000 and 2005 due to carbon sequestration in landfills.

While the distribution of total emissions does not shift significantly, it is important to note that the total emissions have risen steadily over the period studied. Emissions increased by 3.5 percent between 1995 and 2000 and by 8.6 percent between 1995 and 2005. For New York to achieve its target of a 30 percent reduction below 2005 levels by 2030, this upward trend in total emissions will first have to be overcome.

I. Residential, Commercial, Institutional, and Industrial Buildings

New York City is the most densely populated city in the country. Because of the density of New York buildings and the smaller-than-average dwelling unit size, less energy is needed to heat, light, cool, and power New York's buildings than in other U.S. cities, when considered on a per capita basis. New York also has an extensive public transit system, allowing New Yorkers to own cars at far below the national level. Because of this, 79 percent of CO_2e emissions came from New York's buildings in 2005. In comparison, nationally 32 percent of emissions resulted from the operation of buildings.

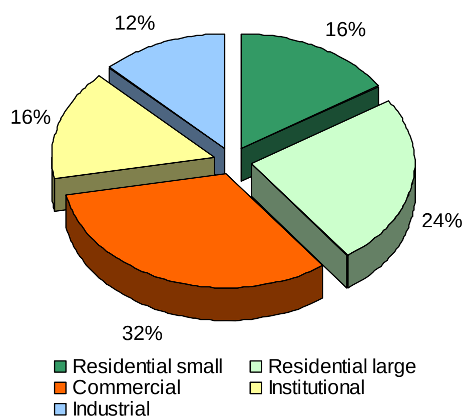

Figure 8. 2005 CO_2e from New York City buildings by sector.

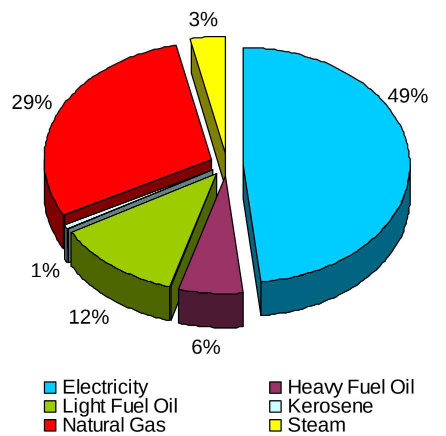

Figure 9. 2005 CO_2e from New York City buildings by source.

Figure 8 above shows the breakdown of CO_2e emissions by building sector in 2005. As shown, 40 percent of emissions are attributable to the energy used by residential buildings. Figure 9 shows the breakdown of energy sources that were responsible for the buildings sector's CO_2e emissions in 2005. Electricity production results in 49 percent of the building sector's CO_2e emissions, while natural gas combustion accounts for 29 percent.

II. Transportation

Fossil fuels used to power cars, trucks, and mass transit in New York City resulted in the emission of approximately 13.6 million metric tons of CO_2e in 2005, representing 23 percent of total emissions. As shown in Figure 10 below, New York's extensive mass-transit system is estimated to transport approximately 40 percent of all people traveling in New York by motorized transportation on a typical weekday (excluding heavy trucks), while only resulting in 12 percent of transportation CO_2e emissions, and 3 percent of overall CO_2e emissions. Total trips by auto, while transporting 55 percent of people traveling in the city by motorized transportation, account for 78 percent of transportation emissions, and 18 percent of overall CO_2e.[13] These data point clearly to greenhouse gas reductions possible as a result of increased use of mass transit.

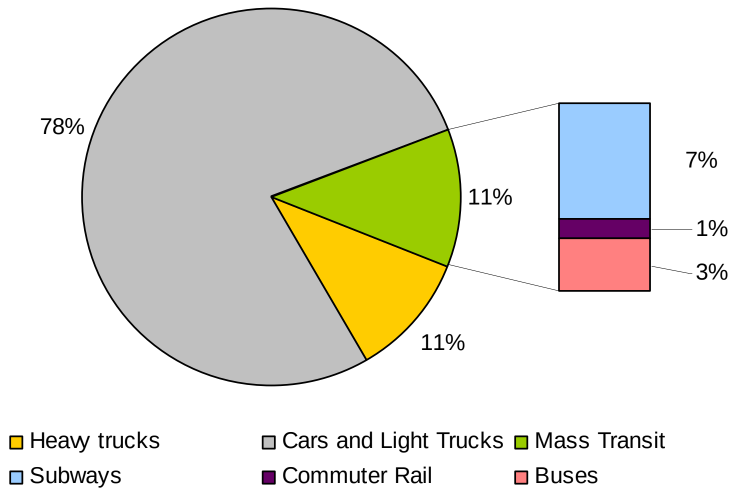

Figure 10. 2005 New York City CO_2e emissions from transportation. 78 percent of CO_2e emissions are caused by only 55 percent of total motorized trips, while 11 percent of CO_2e emissions resulting from mass transit account for 40 percent of all motorized trips.

III. Solid Waste

Because the majority of New York's solid waste is disposed of in managed landfills, and because landfills accepting New York's waste are estimated to capture 75 percent of the methane that is generated through the anaerobic decomposition of the organic matter in waste, disposal of this waste resulted in net CO_2e emissions of approximately -1.5 million metric tons in 2005. Although emissions from long-haul transport are included in the government inventory, they have also been counted toward the citywide total to ensure as accurate an accounting of the city's CO_2e emissions as possible. When emissions from this source are included with solid waste emissions, the net total is -1.2 million metric tons.

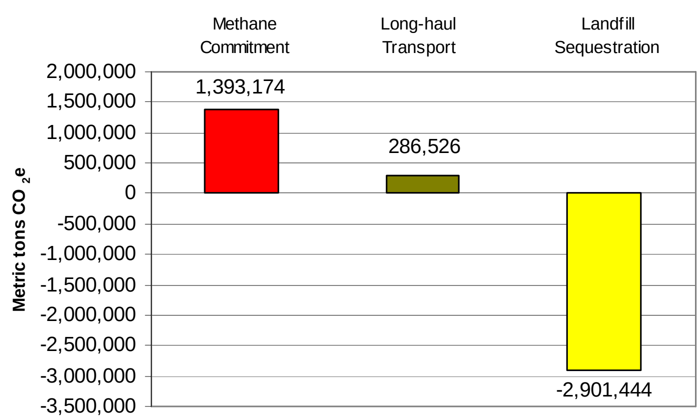

Figure 11. CO_2e emissions from New York City solid waste, 2005. Methane capture in landfills results in net negative emissions due to continued carbon sequestration.

[13] Motorized trips data from NYMTC, *Regional Travel – Household Interview Survey*, 2000.

Emissions from in-city transport of solid waste, both by DSNY and commercial waste carters, are assumed to be captured in the transportation emissions as calculated from NYMTC's VMT estimates (methane emissions from water pollution control plants are also counted toward the citywide total, as they otherwise would not have been included). Figure 11 above illustrates the impact of this combination of methane capture and carbon sequestration.

IV. Aviation and Shipping

As explained previously in the Methodology section of this report, CO_2e emissions from aviation and shipping are not included as part of New York City's reported total greenhouse gas footprint. However, as shown in Figure 12, were these emissions to be included in New York's total, they would constitute significant emissions sources, with aviation responsible for 14 percent of total CO_2e emissions, or 10.4 million metric tons, and the transportation of freight by water accounting for 8 percent of total CO_2e emissions, or 6.2 million metric tons.

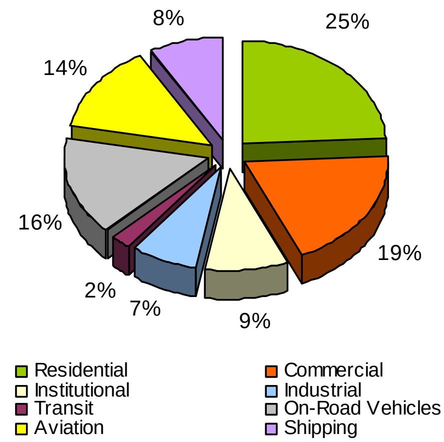

Figure 12. 2005 New York City CO_2e emissions, accounting for shipping and aviation (75 million metric tons)

V. Reduction Target and Forecast

New York has set the goal of reducing its greenhouse gas emissions by 30 percent below 2005 levels by 2030. This target was selected because it was determined to be aggressive yet achievable. The emissions reductions realized through achieving this

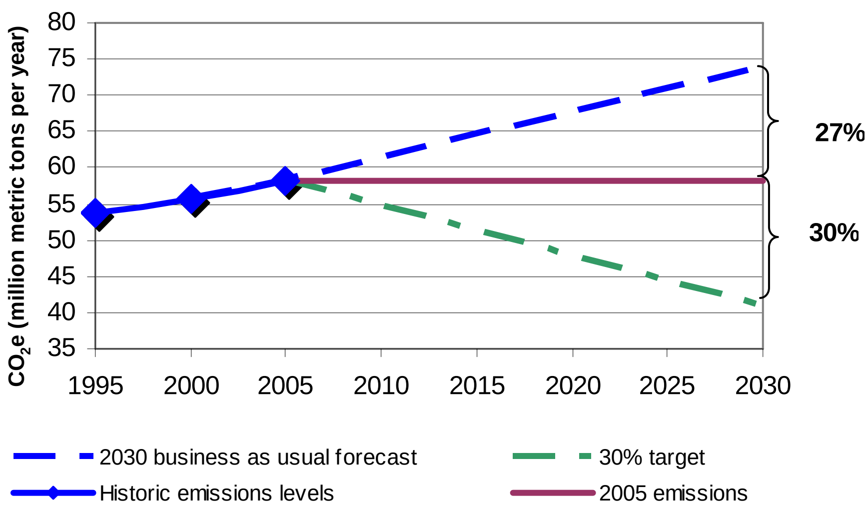

Figure 13. New York citywide CO_2e emissions forecast and target.

target are significantly greater than those that would be realized using ICLEI's recommended 20 percent reduction. Strategies by which the City plans to reach this goal will be outlined in PlaNYC. Figure 13 above illustrates the challenge New York faces. As emissions are projected to increase by 27 percent in a business-as-usual scenario by 2030, New York must first overcome this rise before it can begin to make progress on reducing emissions below 2005 levels.

GOVERNMENT INVENTORY METHODOLOGY

1. General Overview of the Government Greenhouse Gas Inventory

The greenhouse gas emissions inventory included in this section documents emissions resulting from New York City government operations, activities, and facilities in Fiscal Years 1995, 2001, and 2006. Emissions from facilities and fleets owned and leased, as well as from operations that take place in facilities owned or leased by New York City, are included. These municipal emissions were singled out because the City government ultimately has greater control over its own emission-producing actions, such as building heating and cooling, than over those resulting from private activities within its jurisdiction. Government operations that are not directly controlled by the New York City government (subways and buses operated by the Metropolitan Transportation Authority, for example,), as well as energy and fuel used by private entities contracted by New York City, are not included in these inventories, unless otherwise noted.

While government greenhouse gas inventories completed as part of the Cities for Climate Protection Campaign typically include only those sources under direct city government control, additional analyses were completed for several sources that the City influences through regulatory or contractual processes, as noted below. The New York City government inventory consisted of the following sectors:

Direct City Government Control

- **Buildings**: Electricity, natural gas, fuel oil, coal, and steam consumption from City-owned buildings and facilities.
- **Vehicle Fleet**: Gasoline and diesel fuel used by various City-owned or leased motor vehicles such as passenger cars, motorcycles, trucks, and marine vehicles, as well as privately operated school buses contracted by the Department of Education and trucks and trains contracted by the Department of Sanitation for the export of solid waste. Compressed natural gas (CNG) used in City vehicles is not included due to lack of data availability.
- **Streetlights**: Electricity use resulting from the operation of outdoor lighting such as streetlights, traffic signals, illuminated pedestrian signs, and parks and recreation lights.
- **Water and Sewer**: Electricity, natural gas, and fuel consumption from water pollution control plants, wastewater pumping stations, water pumping stations, and all other Department of Environmental Protection facilities, including offices.
- **Solid Waste**: Amount and composition of waste generated by City employees at the buildings and facilities operated by the City.

Indirect City Government Impact

- **Taxis and for-hire vehicles**: Gasoline used by medallion taxis and for-hire vehicles (livery cabs, limousines, “black cars”) licensed by the New York City Taxi and Limousine Commission.

- **City Employee Commute**: Gasoline used by City employees who commute to work by automobile.

2. Base Year and Background Years

The base year for analysis, Fiscal Year 2006 (July 1, 2005 – June 30, 2006) was chosen because the City's financial records are fiscal year-based and Fiscal Year 2006 was the most recent complete fiscal year (any reference to year in this section of the report indicates City fiscal year, unless otherwise noted). Background years of 1995 and 2001 were also analyzed to determine trends and to evaluate the effects that certain policies and actions have had on greenhouse gas emissions. As shown in Figure 14 below, emissions from the operation of New York City's government accounted for 5 percent of emissions citywide.

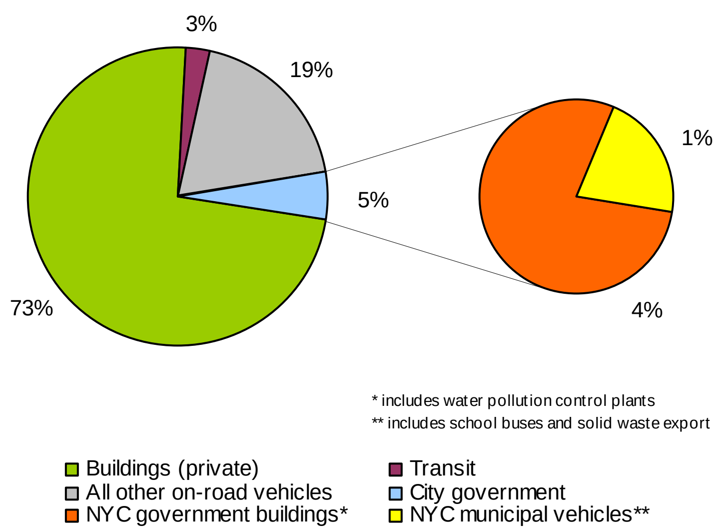

Figure 14. 2006 New York City government CO_2e emissions as a subset of 2005 citywide emissions (buildings and transportation only).

3. Buildings Sector

All buildings owned and operated by New York City and City agencies that occupy leased space have their utility bills processed and stored by the Office of Energy Conservation (OEC) in the Department of Citywide Administrative Services (DCAS). OEC provided the electricity, natural gas, steam, and coal consumption and expenditure data from 1995, 2001, and 2006 for all facilities for which the City pays bills. In addition, OEC provided some data on light and heavy fuel oil consumption. Remaining data for light and heavy fuel oil consumption were provided by DCAS's Division of Municipal Supply Services or by individual agencies where necessary.

There are four individual utility companies that supply electricity and natural gas to City buildings: KeySpan; Consolidated Edison Company of New York (Con Edison); The New York Power Authority (NYPA); and the Long Island Power Authority (LIPA). The quantity of electricity used was multiplied by the coefficient described in Appendix A. This coefficient describes “average” grid electricity in New York City. While it is true that much of the City government’s supply is provided from dedicated sources, the grid is interconnected, and it was determined that the impacts of marginal decisions would be best modeled by utilizing the citywide average.

Data for the use and cost of fuel oil and coal were provided by DCAS and individual agencies. Fuel oil was divided into categories by grade numbers. For the purposes of this inventory, fuel oil was further divided into distillate (light) fuel oil and residual (heavy) fuel oil, with numbers 1, 2, and 4 being distillate oils and numbers 5 and 6 classified as residual oils. Diesel fuel used for backup generators was not counted separately due to lack of data availability.

Greenhouse gas emissions that resulted from steam use by City buildings were calculated by converting Mlbs (thousands of pounds) metered by 1.687 to determine MMBTU.[14] Total MMBTU were then multiplied by the coefficient described in Appendix A to determine CO_2e emissions.

All data from the buildings sector were entered into the CACP software program by agency name and fuel type along with respective expenditures. The ten agencies that consume the most energy were entered separately, while the remaining agencies were aggregated into an “other” category. It is important to note that utility usage and cost for various fuel types for the buildings and facilities operated by the Department of Environmental Protection (DEP) were separated from the buildings sector and included in the sewage and water sector below, per ICLEI recommended methodology.

4. Employee Commute

Although not considered part of the direct government operations, emissions from City employees who drive to work were analyzed to assess their relative contribution to New York’s carbon footprint. The U.S. Census Bureau’s Public Use Microsample database was used to determine journey-to-work information for respondents who classified themselves as employees of local government. Of these, 53 percent indicated that they commute to work by car. An average length-of-commute time was calculated and multiplied by 15 miles per hour, the average weekday peak period speed on City arterials, obtained from NYMTC, to obtain total vehicle miles traveled.

[14] Formula provided by Con Edison. Steam is released from Con Edison’s plants at 125 pounds per square inch (psi). At this pressure, it is at 1193 Btu per pound. Because the steam is reduced in quantity by 14 percent, on average, during delivery, for each pound purchased, 1.16 pounds are produced. Con Edison estimates its steam boilers operate at 81 percent efficiency, on average. Water used to produce steam, delivered at 50 degrees F, on average, has a Btu content of 18 Btu per pound. Fuel consumption per pound of steam purchased, therefore, is determined through the formula (1193 Btu/pound – 18 Btu/pound) x 1.16/0.81, resulting in a conversion factor of 1,687 btu/pound.

5. Taxis and For-hire Vehicles

Taxis and for-hire vehicles (livery cabs, limousines, and corporate fleets, or “black cars”) are privately operated and are not under the direct control of New York City government. However, the New York City Taxi and Limousine Commission (TLC) does regulate these vehicles. Because of this, TLC has the opportunity to implement measures that may result in a decrease in CO_2e emissions. As with City employee commuting, emissions from taxis and for-hire vehicles are not counted toward the City government’s total CO_2e level, but are reported here to demonstrate their contribution to the City’s overall carbon footprint.

Medallion taxi (yellow cabs) vehicle miles traveled (VMT) were calculated using data obtained from *The New York City Taxicab Factbook* (Schaller Consulting, 2006), which reports total cruising miles for the analysis years.[15] Using Schaller’s assumption that 40 percent of total VMT are cruising miles, total VMT for the medallion fleet were calculated for each analysis year. The majority of New York City taxis are estimated by TLC to achieve a fuel efficiency of 13 miles per gallon under field conditions. The model was customized to reflect this.

For-hire vehicle VMT was calculated by multiplying the number of TLC for-hire licenses issued in each analysis year by an average VMT per vehicle of 34,700 miles, which was calculated using New York State Department of Environmental Conservation (DEC) inspection records for these vehicles. As the majority of the for-hire fleet vehicles are models similar to medallion taxis, a fuel efficiency of 13 miles per gallon was assumed.

6. Municipal Vehicle Fleets

The New York City Office of Management and Budget (OMB) gathered data on fuel consumption and cost for Fiscal Years 1995, 2001, and 2006 from each City agency with a substantial vehicle fleet. The following New York City agencies are included in this group: Department of Correction (DOC), Department of Health and Mental Hygiene (DOHMH), Department of Sanitation (DSNY), Department of Transportation (DOT), Department of Citywide Administrative Services (DCAS), Department of Environmental Protection (DEP), Department of Juvenile Justice (DJJ), Department of Parks and Recreation (DPR), Fire Department (FDNY), and the Police Department (NYPD). It should be noted that there are numerous other City agencies that operate smaller vehicle fleets and were not asked to report data. It was estimated by the DCAS Fleet Administration Director that the ten agencies listed above operate the majority of the New York City vehicle fleet and that their heavy use accounts for almost all of the total fuel consumption. Therefore, the total vehicle emissions reported in this inventory do not represent 100 percent of City vehicle emissions, but give a very close approximation that is useful for the purposes of this analysis. Data on consumption and cost were self-reported by agencies to OMB. Where significant data gaps existed, individual agencies were surveyed to determine fuel consumption for particular fuel categories. Remaining gaps were populated using data from other years as proxies. As only total fuel

[15] *The New York City Taxicab Fact Book*. Schaller Consulting, 2006.

consumption data were available, assumptions were made as to what vehicle type each fuel was used for based on agency mission.

7. School Buses

School buses in New York City are privately operated under Department of Education (DOE) contract. Although these vehicles are not operated directly by the City, the City does exert control over their operation through the contracting process. As such, these vehicles have also been included in the government inventory. School bus VMT data for both diesel and gasoline buses were provided by DOE for each analysis year.

8. Long-haul Export of Solid Waste

Since the closure of Fresh Kills Landfill in 2001, all solid waste generated in New York City is exported to landfills or waste-to-energy facilities out of the City. At present, this waste is transported by a combination of heavy trucks and rail cars. Upon the implementation of the Comprehensive Solid Waste Management Plan in 2010, solid waste will be transported almost exclusively by marine barge and rail, significantly reducing greenhouse gas emissions. Solid waste is hauled by private operators under Department of Sanitation contract. As with school buses, the emissions from these vehicles have been included in the government inventory because the City has control over their operation through the contracting process. Emissions from long-haul waste transport were calculated from tonnage and transport mode data provided by DSNY and converted into gallons of diesel fuel using U.S. Department of Transportation methodology that assumes one gallon of diesel moves one short ton of solid waste 59 miles by truck or 202 miles by rail.[16]

9. Streetlights

The New York City Department of Transportation (DOT) is responsible for the operation and maintenance of all streetlights, traffic signals, and illuminated pedestrian signals within the five boroughs. All outdoor lighting found in New York City parks, playgrounds, and other areas of recreation falls under the jurisdiction of the Department of Parks and Recreation (DPR). However, DCAS processes and stores the electricity bills for City agencies. It is not possible to separate electricity use and cost into distinct accounts, types of lighting, or agency control. DCAS, therefore, supplied the usage and cost data of all outdoor lighting in one lump sum, which were entered as such into the CACP software.

10. Water and Sewer

The water and sewer section of the inventory includes all water pollution control plants, wastewater pumping stations, water pumping stations, and all buildings and facilities operated by the Department of Environmental Protection (DEP) (offices, maintenance

[16] U.S. Department of Transportation Maritime Administration, *Environmental Advantages of Inland Barge Transportation*, August 1994.

facilities, etc.), as well as methane generated during the wastewater treatment process. Because these facilities tend to use large amounts of electricity, natural gas, and fuel oil, their emissions inventory data are separated from the buildings inventory for further analysis. All such facilities (located both in the City and in the watershed in upstate New York) are controlled and operated by DEP, although DCAS compiles the financial records.

Methane generated during the treatment of wastewater was quantified and provided by DEP. While most of the methane generated during the treatment process is either flared or used productively in the treatment process, a small amount does escape into the atmosphere through system leaks or malfunctions. As anaerobic digester gas production at the City's water pollution control plants increased by roughly 15 percent over the last ten years, an annual average rate of increase in methane emissions of 1.5 percent was assumed and applied to both background years and the forecast year.

11. Solid Waste

All solid waste collected from City buildings and offices in Fiscal Years 1995, 2001, and 2006 was transported to landfills along with solid waste from New York City as a whole. Once it is brought to the landfill (Fresh Kills Landfill in 1995 or landfills outside the city in 2001 and 2006), determining the origin of the waste is impossible. Therefore, an alternate method for estimating the amount of greenhouse gas emissions from this sector was used.

The New York City Department of Sanitation conducted a Waste Composition Study in 1990 and found that each New York City government office employee generated 0.54 metric tons of solid waste annually, recycling 0.05 metric tons (almost all paper) and sending 0.49 metric tons to landfill.[17] Because not all employees work in an office setting on a daily basis, DEP, DPR, and DOT were surveyed to determine the percentage of their employees who work in an office and therefore generate solid waste that can be considered typical of a government office worker. This number of employees was added to the total number of office employees, as reported in the Mayor's Management Report. The balance from these three agencies was added to the number of non-office employees (uniformed) workers from FDNY, NYPD, DOC, and DSNY. Each category of employee (office employee and non-office employee) was entered into the CACP software separately, with the number of employees multiplied by the amount of waste landfilled annually per employee to arrive at the total tons landfilled in Fiscal Years 1995, 2001, and 2006. Waste share percentage variables were set in the CACP software for each employee category, based on DSNY's 1990 Waste Composition Study. This document was used to obtain a breakdown of the percentage by weight of different waste types for office employees, while the ICLEI recommended default waste share percentages were entered for uniformed employees. As seen in Table 2, the primary difference is that office workers are assumed to generate far more paper than non-office workers. This change results in different levels of greenhouse gas emissions from the decomposition of this waste for each employee category.

[17] SCS Engineers (1992) *New York City Waste Composition Study (1989-1990)*, DSNY.

Table 2. Waste share percentages for government inventory.

Waste Type	Office workers	Non-office workers
Paper	81.92%	38%
Food Waste	1.90%	13%
Plant debris	0.13%	10%
Wood/textiles	2.78%	4%
Other (non-organic)	13.26%	35%

The CACP software does not allow users to enter different landfill methane capture rates for different analyses years. Due to this limitation, and because methane capture rates (both at Fresh Kills and at out-of-city landfills) changed from 1995 to 2006, each year's solid waste figure was calculated separately in the CACP software "Waste" sector using that year's methane capture rate, and the resulting CO_2e figure entered into the CACP software's "Other" sector as absolute CO_2 emissions, per ICLEI guidance. DSNY estimated that the landfill capture rate at Fresh Kills was 25 percent in FY 1995. By FY 2001, most of New York City's solid waste was exported as Fresh Kills Landfill prepared to close. For solid waste sent to landfill in 2001, 2006, and in the 2017 Forecast Year, an assumed landfill methane capture rate of 75 percent is used.

12. Emissions Forecast and Reduction Target

The Clean Air Climate Protection (CACP) software used in these analyses calculates a municipality's greenhouse gas emissions for its target year using that year's electricity and fuel coefficients. In this inventory, the City assumed a constant electricity coefficient (2005 level) for all years (including forecast year), whereas vehicle fuel efficiencies were projected to improve slightly between 2006 and 2017. The emissions forecast generated does not take into account planned or active measures, but rather presents a business-as-usual scenario, demonstrating what the emissions level would be were no actions taken. The CACP software generates an emissions forecast for government emissions by copying the base year's inputs into the target year. A list of all coefficients used in this analysis is available in Appendix A of this report.

To reflect a more likely business-as-usual forecast, a background increase in electricity demand was calculated based on the last six years of total electricity demand for City agencies. Based on this demand increase, a 2 percent annual increase in electricity demand was applied and added to the 2017 forecast year. Additionally, DEP estimates that anaerobic digester gas production at the City's water pollution control plants has increased by an average of 1.5 percent per year over the last ten years. This rate of increase was applied to future years to estimate an increase in methane production anticipated by the 2017 forecast year in a business-as-usual scenario.

13. Data Sources

Detailed information regarding all organizations and contacts mentioned in this section can be found in Appendix C of this report.

GOVERNMENT INVENTORY RESULTS

Greenhouse gases emitted as a result of government operations are a subset of citywide emissions, representing approximately 7 percent of the citywide total. As seen in the citywide inventory, energy used in buildings is by far the greatest source of CO_2e emissions. Actions implemented by City government from 1995 to 2006 have avoided the emission of 446,000 metric tons of CO_2e. Actions planned to be implemented from 2007 to 2017 are projected to avoid the emission of 404,000 metric tons of CO_2e. These actions have stabilized City government CO_2e levels, despite a background increase in electricity use. Figure 15 shows the impact of government actions on CO_2e emissions.

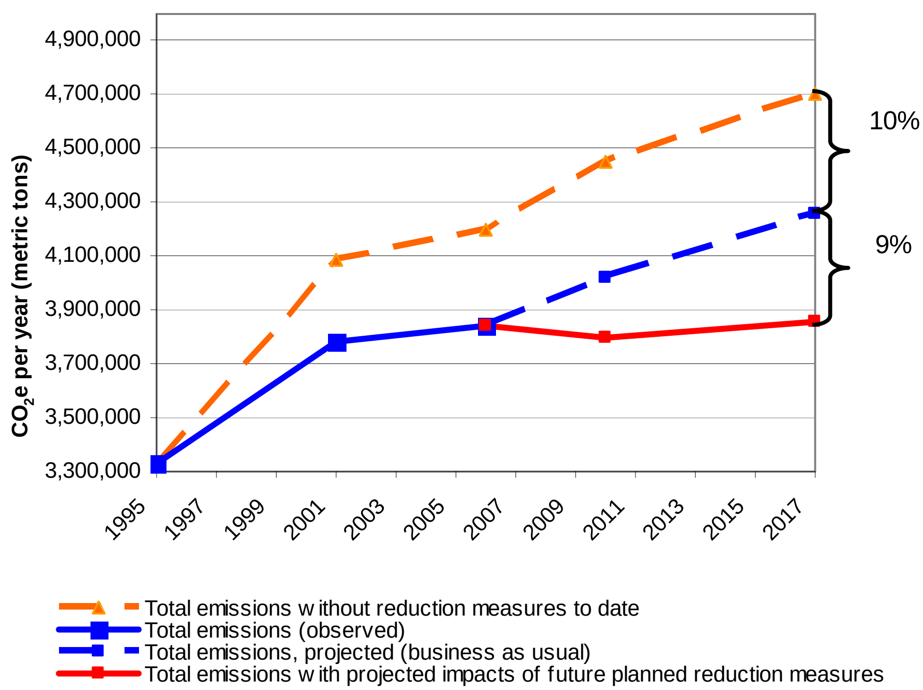

Figure 15. New York City government CO_2e emissions, showing business-as-usual trend and impact of emissions reduction measures.

In Fiscal Year 2006, activities associated with the direct operation of New York City's government (for which records were available) resulted in a total release of approximately 3.8 million metric tons of CO_2e. In addition to this, indirect government impact resulted in approximately 1.8 million metric tons being emitted from taxis and City employee commuting. For the purposes of this report, emissions from indirect government impact are not considered part of the total and are included for reference only. As shown in Figure 16, the production of electricity and steam and the combustion of natural gas and fuel oil used in buildings owned and leased by the City of New York resulted in the majority of emissions in 2006. These buildings were responsible for the emission of approximately 2.4 million metric tons of CO_2e. Emissions of CO_2e

generated by the operation of water pollution control plants, water supply, and wastewater transport systems operated by the Department of Environmental Protection made up 16 percent of emissions with the release of 655,000 metric tons of CO_2e. Gasoline and diesel fuel used by City vehicles (including school buses and DSNY contracted long-haul trucks and trains) accounted for the third largest contribution of emissions at 18 percent, producing 653,000 metric tons of CO_2e. Due to the nature of waste produced in government offices and the amount of methane recovery undertaken in landfills where waste from City employees was taken in 2006, solid waste generated by government resulted in net negative emissions.

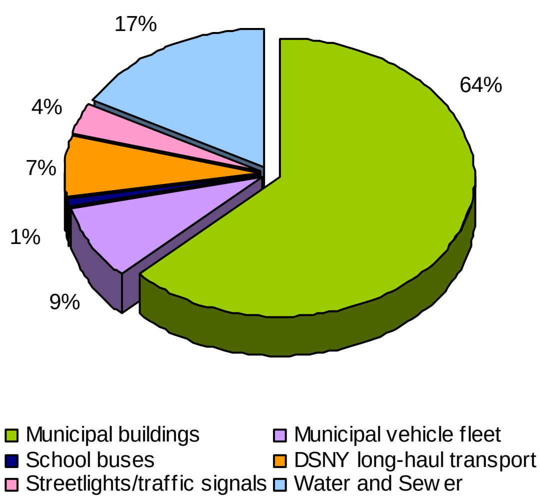

Figure 16. 2006 New York City government CO_2e emissions by sector (3.8 million metric tons).

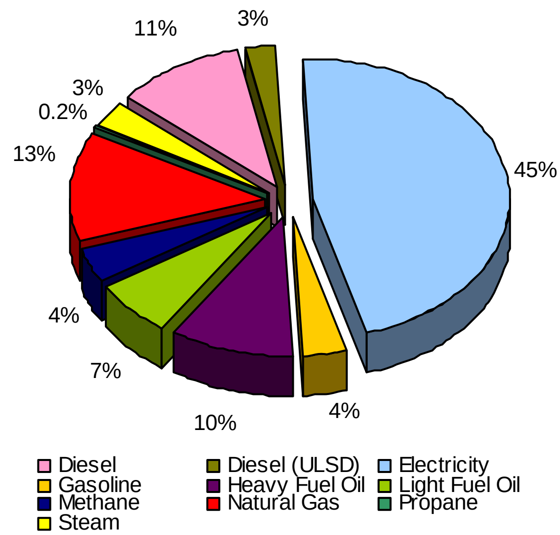

Figure 17. 2006 New York City government CO_2e emissions by source (3.8 million metric tons).

Figure 17 shows clearly the dominance of electricity when 2006 government CO_2e emissions are categorized by source. Table 3 lists CO_2e emissions by sector for each of the analysis years.

Table 3. New York City government CO_2e emission by sector.

New York City Government CO_2e Emissions by Sector (metric tons per year)				
Sector	**1995**	**2001**	**2006**	**% change, '95-'06**
Municipal buildings	2,168,455	2,496,725	2,443,555	12.7%
Municipal Vehicle Fleet	260,484	314,549	335,381	28.8%
School buses	20,060	26,188	30,893	54.0%
DSNY long-haul trucks and trains	-	147,571	286,527	100.0%
Streetlights and traffic signals	194,442	184,461	144,189	-25.8%
Sewage and Water	599,701	663,667	654,793	9.2%
Solid Waste	85,586	(53,022)	(55,106)	-164.4%
Total	**3,328,728**	**3,780,139**	**3,840,232**	**15.4%**

I. Buildings Sector

Energy use in buildings is the largest contributing sector to the greenhouse gas emissions inventory from all City sources. Collectively, energy use in the form of electricity, natural gas, fuel oil, steam, and coal to heat, cool, power, and light City government buildings accounted for 64 percent of emissions in the base year, producing approximately 2.4 million metric tons of CO_2e.

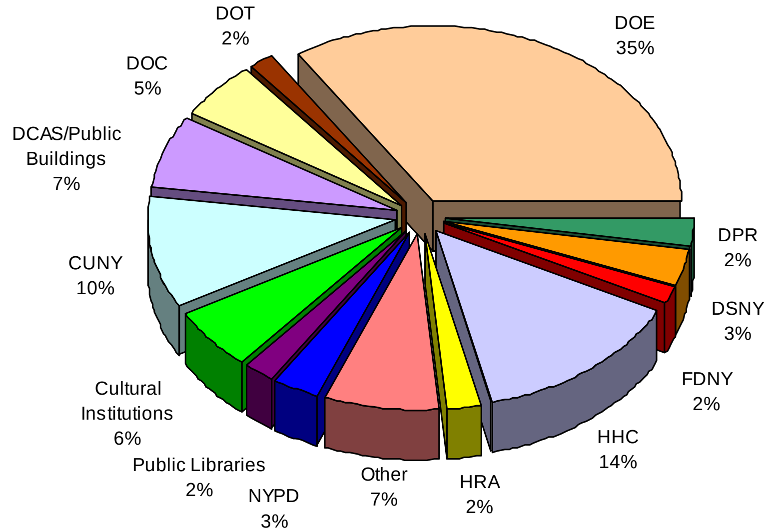

Figure 18. 2006 New York City government buildings CO_2e emissions by agency (2.4 million metric tons).

When classified by agency, the buildings that came under control of the Department of Education were responsible by far for the most emissions, as can be seen in Figure 18. Energy used by the City's schools and the administrative buildings that house the Department of Education accounted for 35 percent of total emissions in the buildings sector in 2006. The numerous individual institutions that comprise the Health and Hospitals Corporation and the City University of New York (CUNY) contributed 14 percent and 10 percent of emissions, respectively, placing them as the second- and third-highest emitting agencies in the buildings sector.

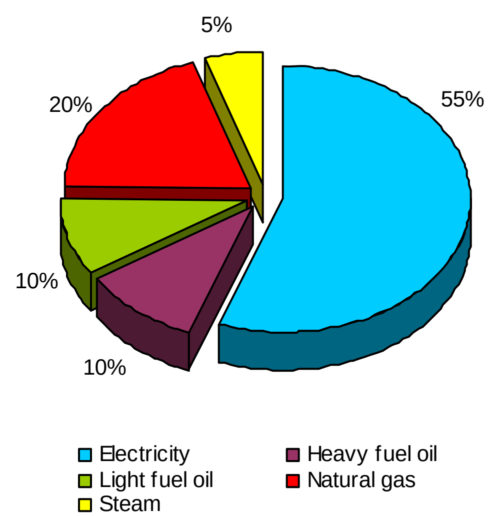

Figure 19. 2006 government buildings sector CO_2e emissions by source (2.4 million metric tons).

Figure 19 illustrates the breakdown of energy sources that are responsible for the greenhouse gas emissions from the operation of New York City's government buildings and facilities. As shown, the generation of electricity is responsible for more than half of the City's CO_2e emissions, further demonstrating the importance of energy efficiency measures in City buildings.

II. Employee Commute Sector

Employee commuting by automobile is estimated to have resulted in the emission of approximately 251,000 metric tons of CO_2e in 2006. As these emissions are not considered to be directly related to the operation of the City government, they have not been included in the total emissions figure. CO_2e emissions generated by City employees traveling by mass transit are assumed to be captured in the citywide inventory.

III. Taxis and For-hire Vehicles Sector

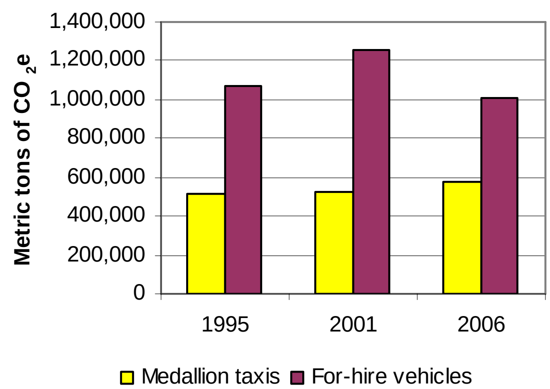

Figure 20. New York City taxi and for-hire vehicle CO_2e emissions.

Although New York City taxis and for-hire vehicles are privately owned and operated, emissions generated from their operation have been included in this report as a point of reference only and are not counted toward the government's total CO_2e level. Because each of the city's 13,000 medallion taxis is estimated to drive more than 100,000 miles per year, and because the majority of these vehicles are estimated to get only 13 miles to the gallon, taxi CO_2e emissions are significant. The city's for-hire vehicle fleet is almost three times as large as the medallion fleet. Emissions are therefore much higher for these vehicles. Medallion taxis emitted approximately 580,000 metric tons of CO_2e in 2006, while for-hire vehicles emitted approximately 1 million metric tons. Were these vehicles to be included in the government total, they would be responsible for 28 percent of government CO_2e emissions. Figure 20 illustrates the taxi and for-hire vehicle emissions from 1995-2006. As shown, emissions from for-hire vehicles declined from 2001 to 2006. This decline was due to a reduction in the number of licenses issued by the TLC.

IV. Vehicle Fleet Sector

New York City municipal fleet vehicles (excluding school buses and DSNY long-haul trucks) consumed a total of 15.4 million gallons of diesel fuel (including Ultra Low Sulfur Diesel, ULSD) and 10.5 million gallons of unleaded gasoline in Fiscal Year 2006, the combination of which resulted in the production of 335,000 metric tons of CO_2e, comprising 8.7 percent of emissions from City operations.

When the amount of greenhouse gas emissions from vehicles is broken down by agency, as illustrated in Figure 21 (not including school buses or DSNY long-haul transport), it becomes clear that the Department of Sanitation fleet is responsible for the majority of emissions at 31 percent. The Police Department fleet was second highest, at

29 percent of emissions, followed by the Department of Transportation with 18 percent of total emissions from the vehicle fleet (including Department of Transportation ferries, e.g. the Staten Island Ferry). Emissions generated from the combustion of diesel fuel (including ULSD) accounted for 5.2 percent of total government CO_2e emissions in 2006, while gasoline combustion accounted for 3.9 percent of total government CO_2e. Figure 22 illustrates the breakdown of fuel types responsible for the vehicle fleet's CO_2e emissions.

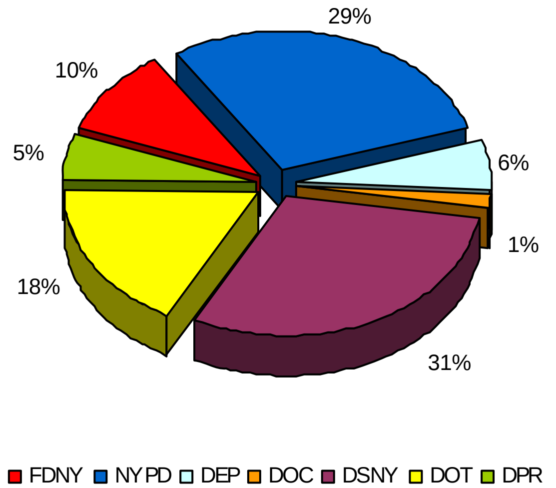

Figure 21. 2006 New York City municipal vehicle fleet CO_2e emissions by agency share (335,000 metric tons).

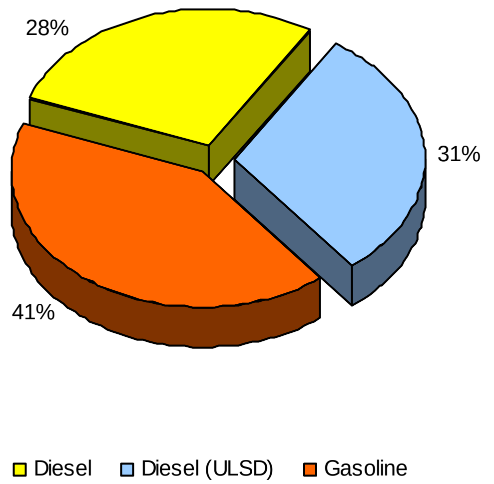

Figure 22. 2006 New York City municipal vehicle fleet CO_2e by source (335,000 metric tons).

V. School Buses Sector

Although school buses are privately operated, the City does exert some control over their operation. Because of this, they have been included in the government inventory. In 2006, school buses emitted approximately 31,000 metric tons of CO_2e. School bus emissions have increased since 1995 by approximately 54 percent, due to a significant increase in VMT. This VMT increase is due to the addition of new bus routes and expanded school bus service, including additional special education and summer programs.

VI. Solid Waste Export Sector

With the closure of Fresh Kills Landfill in 2001, DSNY began to export solid waste out of the city using tractor trailer trucks. Like school buses, these vehicles are not operated directly by the City, but are privately operated under DSNY contract. CO_2e emissions associated with these vehicles have been included because the City influences their operation through the contracting process. In 2006, the export of solid waste resulted in the emission of approximately 287,000 metric tons of CO_2e. As long haul exporting of waste did not begin until after the 1995 background year, CO_2e emissions from this source increased steadily as Fresh Kills gradually closed from 1998 to 2001. As detailed in the Reduction Measures section of this report, CO_2e emissions will be reduced significantly upon implementation of the Solid Waste Management Plan (SWMP).

VII. Streetlights and Traffic Signals Sector

Electricity consumption from New York City streetlights, traffic lights, and illuminated pedestrian signals accounted for 3.7 percent of government greenhouse gas emissions in Fiscal Year 2006, resulting in the release of 144,000 metric tons of CO_2e. As noted in the Reduction Measures section of this report, this sector has seen the greatest percentage reduction in CO_2e over the 11-year period from 1995 to 2006 due to the citywide installation of light emitting diodes (LED) traffic and pedestrian signals. Figure 23 illustrates this 26 percent reduction in greenhouse gas emissions.

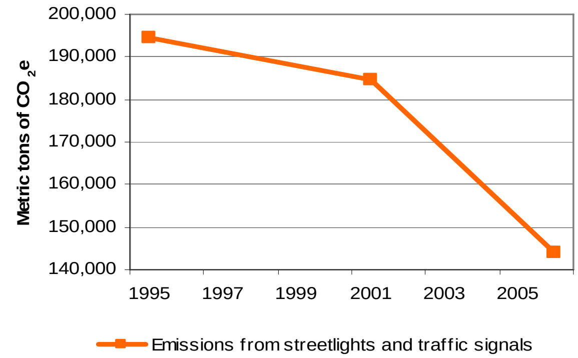

Figure 23. CO_2e emissions from New York City streetlights and traffic signals, 1995-2006.

VIII. Water and Sewer Sector

The facilities that make up the wastewater treatment and water and sewer systems that serve a municipality are often the buildings that use the greatest amount of energy; therefore, they are removed from the buildings sector for more specific examination. DEP-operated water pollution control plants, water supply, and wastewater transport systems, together with methane generated by the wastewater treatment process that escapes into the atmosphere, combined to produce 17 percent of emissions from City operations in 2006. It should be noted that New York City's water supply system is almost entirely gravity-fed. Therefore, the vast majority of energy consumed by this sector was used for wastewater transport and treatment. A total of approximately 655,000 metric tons of CO_2e were emitted by this sector in 2006.

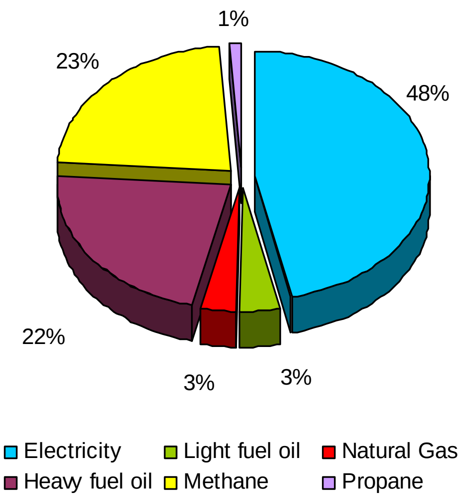

Figure 24. 2006 New York City government water and sewer CO_2e emissions by source (655,000 metric tons).

As illustrated in Figure 24, indirect emissions from electricity consumption dominated the greenhouse gas emissions from the water and sewage sector in 2006, responsible for 48 percent of emissions. A significant percentage of the methane generated during sewage treatment was either flared or captured and used for energy as part of the treatment process. The CO_2 generated by this combustion was excluded from this report as any amount of CO_2 released from methane flaring is equal to or less than that which would be emitted if the organic matter decomposed on its own in an aerobic environment. However, a small fraction of total methane generated through the anaerobic digestion process is estimated to leak into the atmosphere due to system leaks or malfunctions. The 150,000 metric tons of CO_2e that accounts for this methane leakage represents 23 percent of the emissions from the sewer and water sector and 3.9 percent of the City's total CO_2e emissions.

IX. Solid Waste Sector

It is estimated that during Fiscal Year 2006, approximately 194,000 metric tons of solid waste were generated from New York City government employees and sent to landfills.

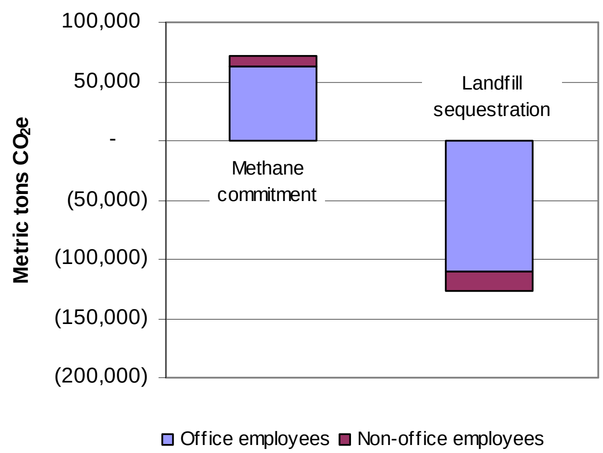

Figure 25. 2006 CO_2e emissions from New York City employee solid waste (net -55,000 metric tons)

Waste contributes to greenhouse gas emissions through the release of methane gas as the waste decomposes. In 1994-95 at Fresh Kills Landfill, methane capture was approximately 25 percent. By 2006, methane capture at landfills accepting New York City waste is assumed to be 75 percent. Due in large part to this level of methane capture, total greenhouse gas emissions generated from the decomposition of City employees' waste in 2006 was a net negative of approximately -55,000 metric tons of CO_2e.[18] Figure 25 above illustrates the percentage of methane generated and the amount of carbon that is sequestered in the landfill.

[18] Methane recovery data obtained from New York City Department of Sanitation.

GOVERNMENT GREENHOUSE GAS EMISSIONS REDUCTION MEASURES

An assessment of New York City government's contribution to citywide greenhouse gas emissions would be incomplete without including an assessment of measures that have already been implemented and have had the effect of reducing CO_2e emissions. For the purpose of this analysis, CO_2e emission reduction measures have been grouped into two categories: those implemented between 1995 and 2006, and those measures that will be implemented between 2006 and 2017. Measures are classified by those that result in either avoided emissions, such as energy efficiency measures that result in fewer emissions, and actual emissions reductions, such as carbon sequestration though increased tree planting. Measures implemented to date have resulted in the avoidance of the emission of more than 446,000 metric tons of CO_2e annually, while those that are scheduled to be implemented by the 2017 target year are anticipated to result in annual avoidance of 404,000 metric tons of CO_2e. Had these measures not been in place, City government CO_2e emissions would have been 13 percent higher in 2006, and would be almost 20 percent higher than 2006 levels in 2017. Figure 26 illustrates the impact of reduction measures on City government greenhouse gas emissions to date.

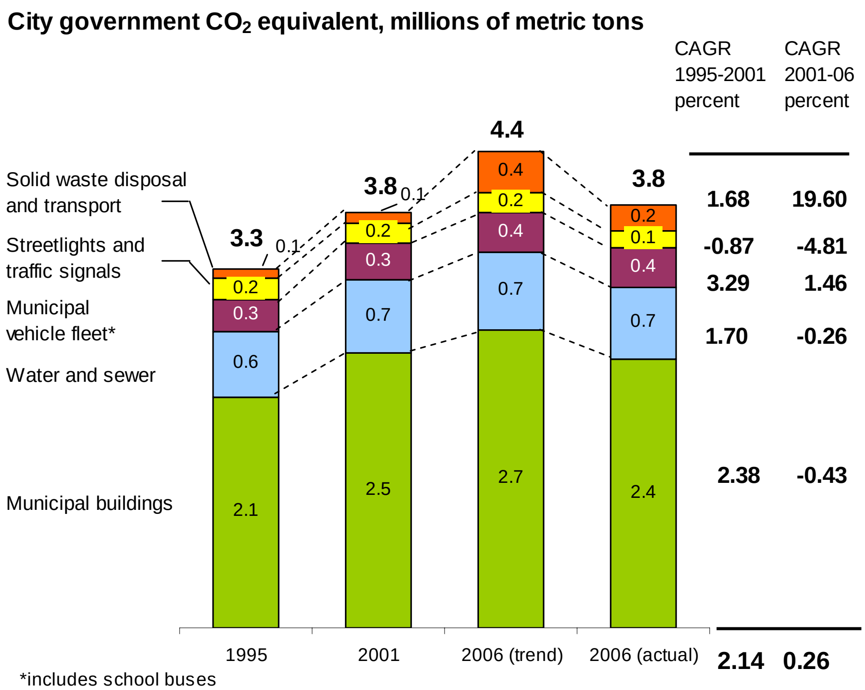

Figure 26: City government CO_2e, millions of metric tons. Actions taken by the City government have stabilized emissions from 2001 to 2006.

IMPACTS OF REDUCTION MEASURES TO DATE

New York City has already begun implementing measures that contribute to reducing the City government's greenhouse gas emissions. These measures include, among others, energy reduction programs, street tree-planting programs, conversion of streetlights to more efficient technologies, landfill methane recovery, use of alternative fuel vehicles, and solid waste recycling. Figure 27 illustrates each measure's contribution to the total annual avoidance of 446,000 metric tons of CO_2e emissions. These measures demonstrate the progressive policies of the past ten years and point toward the fact that with more concentrated effort New York will be able to achieve even more substantial reductions in the future.

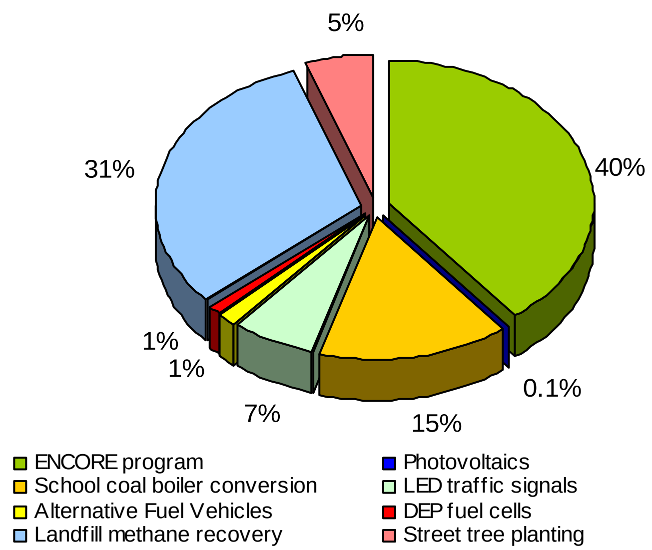

Figure 27. 2006 CO_2e reduction measures by share (446,000 metric tons).

1. ENCORE

The Energy Cost Reduction program (ENCORE)[19] provides for energy conservation and clean technology projects in City facilities. The ENCORE program, started in 1995, is based on a contract between the New York Power Authority (NYPA), the New York City Department of Citywide Administrative Services (DCAS), the City University of New York (CUNY), and the New York City Health and Hospitals Corporation (HHC). The DCAS Office of Energy Conservation coordinates the ENCORE program on behalf of City agencies.

[19] ENCORE (ENergy COst REduction) is contractual agreement between the New York Power Authority (NYPA) and the New York City Department of Citywide Administrative Services (DCAS) providing for turnkey implementation of energy efficiency and clean energy projects.

ENCORE achieves greenhouse gas emissions reductions through two strategies: increasing the energy efficiency of City buildings and switching to cleaner fuels.

As of the end of 2006, there were more than 350 ENCORE projects in different levels of implementation (preliminary, survey, design, installation, and complete).[20] If all of these projects are implemented as planned, they will result in annual savings of approximately 155,000 MWh of electricity; 878,000 MMBtu (millions of British Thermal Units) of steam; 3,000 tons of coal; and 15.2 million gallons of oil. Because a component of the ENCORE program involves converting equipment to burn cleaner fuels, the use of natural gas will increase by approximately 20 million therms per year. Combined, these programs resulted in the total avoided emission of approximately 176,000 metric tons of CO_2e by 2006. Table 4 below summarizes these avoided emissions.

Table 4. Annual emissions reductions (CO_2e) from ENCORE projects by 2006.

Project	CO_2e Reduction (metric tons)
Rikers Island Powerhouse conversion	40,000
NYPD equipment and lighting upgrades	9,000
Boiler and chiller upgrades	52,000
School lighting retrofits	37,000
Various equipment and lighting upgrades	17,000
Energy management system upgrades	5,000
WPCP process upgrades	7,000
School coal boiler conversion	9,000

Historically, ENCORE was composed of several sub-programs like the Electrotechnologies Program (EP), the High Efficiency Lighting Program (HELP), the Non-Electric End Uses Program (NEEP), the Coal Conversion Program (COAL), and the Distributed Generation program. For the purposes of this analysis ENCORE projects were grouped into the following subcategories:[21]

Rikers Island Powerhouse conversion: Rikers Island is the main base of operations for the City's Department of Correction, containing ten jails housing more than 17,000 inmates. The Rikers Island Powerhouse went through a conversion of its plant in 2001, retrofitting boilers with low-nitrogen oxide burners. This program resulted in a total annual avoidance of 40,000 metric tons of CO_2e.

NYPD equipment and lighting upgrades: The New York City Police Department has upgraded its boilers and/or chillers and also its lighting equipment at various precincts, the Police Academy and Department Headquarters. These projects have avoided the emission of 9,000 metric tons of CO_2e emissions per year.

[20] As of the end of Fiscal Year 2006, 244 ENCORE projects were completed, reducing electricity demand by 16 megawatts and saving more than 87,000 kWh a year in electric energy.
[21] The figures for CO_2e reductions related to ENCORE projects were obtained from the CACP software. Total cost savings figures for each program were provided by DCAS.

City buildings boiler and chillers upgrades: Several hospitals, courthouses, and other City buildings upgraded their boilers and/or chillers under the ENCORE program. These upgrades have resulted in the total annual avoidance of 52,000 metric tons of CO_2e.

School lighting conversion: 181 City schools have implemented lighting upgrades. This program has resulted in a total annual avoided emission of approximately 37,000 metric tons of CO_2e.

Various equipment and lighting upgrades: Additional ENCORE projects, including various equipment and lighting upgrades, have resulted in the annual avoidance of the emission of approximately 17,000 metric tons of CO_2e.

Energy management system upgrades: Starting in 2002, four community colleges and various senior colleges in New York City have undergone energy management system upgrades, resulting in a total annual CO_2e avoidance of 5,000 metric tons.

Water Pollution Control Plant (WPCP) Process Upgrades: Upgrades to pumps and aeration systems at two water pollution control plants have resulted in significant electricity savings, leading to a total annual avoidance of approximately 7,000 metric tons of CO_2e.

School coal boiler conversion: This program, known as COAL, provided public schools in the city that were burning coal with new dual fuel (natural gas/fuel oil) boilers. A total of twelve schools participated in this program between 1998 and 2000. This program attained total annual savings of only $57,000, but had the benefit of eliminating a significant source of air pollution and greenhouse gas emissions. This program resulted in a total annual avoidance of 9,000 tons of CO_2e.

2. School Coal Boiler Conversion

While the ENCORE program funded the conversion of twelve school boilers from coal to dual fuel (natural gas/fuel oil), 288 additional schools received boiler upgrades beginning in 1997, funded by NYPA, the New York City School Construction Authority (SCA), and the New York City Department of Design and Construction (DDC). This initiative has resulted in the annual avoidance of approximately 66,000 metric tons of CO_2e.

3. LED Traffic Signal Conversion

The New York City Department of Transportation (DOT) began a program in 1997 in Queens to replace conventional incandescent bulb pedestrian signs and traffic signals with devices powered by light emitting diodes (LED). This program has now been applied to the rest of the City's boroughs, applying this technology to all 10,700 signalized intersections across the City.

LEDs not only consume less energy but also last six times longer and are much brighter than conventional lights. LED signals have an estimated burning capacity of 100,000 hours—more than 12 years—whereas incandescent bulbs have a lifespan of only 16,000 hours—or about two years. Additionally, LED signals use between 8 and 20 watts, significantly less than the 67 watts the incandescent lights use.[22] This program results in an annual avoidance of approximately 30,000 metric tons of CO_2e.

4. Street Tree Planting Program

The New York City Department of Parks and Recreation estimates that it planted approximately 139,000 street trees between 1995 and 2006.[23] A study completed for DPR estimated that each street tree in New York sequesters and avoids the emission of approximately 0.17 metric tons of CO_2 per year (due to carbon sequestration in the tree's biomass and through reducing the cooling needs of adjacent buildings).[24] Based on this calculation, street trees planted between 1995 and 2006 resulted in the annual combined sequestration and avoidance of 24,000 metric tons of CO_2e by 2006.

5. Alternative Fuels Vehicle Program

New York City's alternative fuel vehicle fleet is the largest in the country, consisting of more than 3,500 alternative fuel vehicles. These vehicles make up 14 percent of the City's 26,000 vehicle fleet. The City's Department of Transportation began retrofitting municipal fleet vehicles to burn compressed natural gas (CNG) in 1993. Since then the program has expanded to now include gasoline/electric hybrid, ethanol, and electric vehicles.[25]

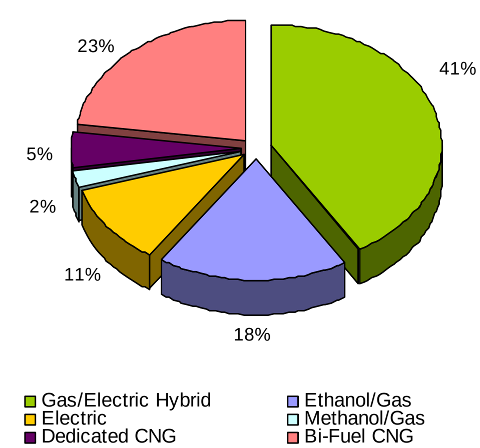

Figure 28**.** New York City alternative fuel vehicle fleet by fuel type, 2006.

The use of alternative fuel vehicles in New York City's municipal fleet resulted in the annual avoidance of approximately 6,000 metric tons of CO_2e emissions As this figure is based on the current fleet

[22] Lifespan and energy use provided by New York City Department of Transportation
[23] Department of Parks and Recreation estimate.
[24] Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station,*New York City, New York Municipal Forest Resource Analysis*, 2007.
[25] New York City Department of Transportation Web site: http://www.nyc.gov/html/dot/html/motorist/alternativefuel.html

composition, it is expected to increase significantly as a greater percentage of the City's fleet is converted to alternative fuel vehicles in the future. Because the forecast for this analysis is based on a business-as-usual scenario, anticipated benefits such as these are not included. Figure 28 above illustrates the current alternative fuel fleet breakdown.

6. Methane Recovery from City Employee Solid Waste

All solid waste generated by New York City employees was sent to Fresh Kills Landfill on Staten Island during the background year of 1995, and was sent to landfills out of the City by 2006. Because methane capture rates changed from 25 percent to 75 percent at Fresh Kills from 1995 to 2001, a significant volume of methane was captured and flared during this period.[26] To be consistent with the Waste Sector CO_2e emissions calculation used for the inventory, this measure quantified the recovery of only the methane generated from the decomposition of solid waste from New York City employees, and only the waste that was sent to Fresh Kills between 1995 and 2001, as any additional methane capture after Fresh Kills's closure in 2001 would not be a measure for which New York could take credit. This measure resulted in the cumulative avoidance of the emission of approximately 136,000 metric tons of CO_2e by 2001.

7. Department of Environmental Protection Fuel Cells

In 2003 DEP partnered with the New York Power Authority (NYPA) to install eight fuel cells powered by anaerobic digester gas at four City water pollution control plants. The electricity generated by these fuel cells is used by the facility in the treatment process, and replaces electricity formerly drawn from the grid. On average, these fuel cells produce 8.24 million kWh of electricity per year, resulting in an annual greenhouse gas avoidance of more than 5,000 metric tons.

8. Photovoltaics

Beginning in 1996, the City has installed photovoltaic arrays at six different locations. Systems have been installed at the Rikers Island composting station, the Bronx High School of Science, the Whitehall Ferry Terminals, the New York Hall of Science, the Queens Botanical Garden, and the Brooklyn Children's Museum. In addition, NYPA installed systems at Public Schools 13 and 14 in Staten Island. Together, these initiatives result in an annual avoidance of approximately 500 metric tons of CO_2e.

[26] Flaring methane has the effect of reducing the potential effect of the gas on global climate change. Although CO_2 is released when methane is flared, the volume of the CO_2 is equal to what would be emitted if the organic matter has decomposed on its own in an aerobic environment, and is hence not considered as part of this emissions inventory.

PROJECTED IMPACTS OF FUTURE PLANNED REDUCTION MEASURES

Measures planned to be implemented between 2006 and 2017 are projected to result in the avoided emission or reduction of 404,000 metric tons of CO_2e each year by 2017. These measures include only those which are known to become implemented during this period, either through existing local law, contract, or other agreement. By 2017, these measures are expected to result in only a small reduction of CO_2e levels below 2006 of 0.3 percent. As the sum of total reductions is approximately 404,000 tons of CO_2e per year, it is apparent that without these measures emissions would have increased by almost 10 percent.

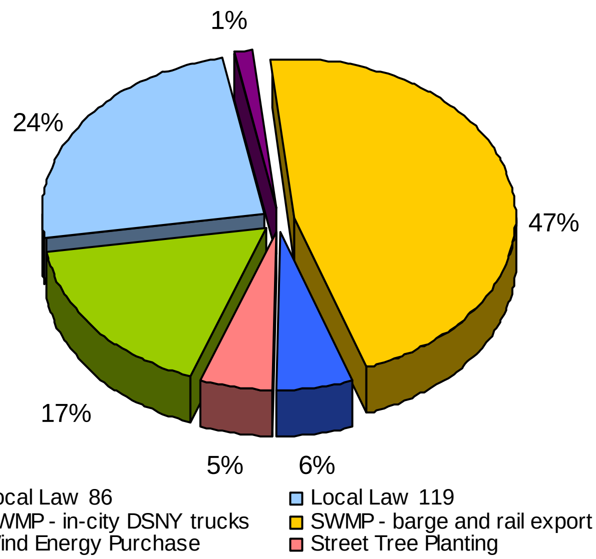

Figure 24. 2017 Projected CO_2e reduction measures by share (404,000 metric tons).

1. Solid Waste Management Plan – VMT Reduction for DSNY Trucks

New York City's revised Comprehensive Solid Waste Management Plan (SWMP) will require that New York City's solid waste be exported from the city by marine barge and railroad instead of tractor trailer trucks. This change will lead to an annual reduction of approximately 2.75 million vehicle miles traveled (VMT) in-city by DSNY trucks, resulting in the avoidance of approximately 5,000 metric tons of CO_2e emissions per year by the target year of 2017.[27]

2. Solid Waste Management Plan – VMT Reduction for Long-Haul Trucks

Upon implementation of the SWMP, solid waste transferred out of the city will be carried by a combination of marine barge and freight train. Data provided by DSNY were used

[27] DSNY, *Comprehensive Solid Waste Management Plan Final Environmental Impact Statement*, 2006. Available online at http://www.nyc.gov/html/dsny/html/reports/swmp-4oct.shtml.

to calculate the expected decrease in CO_2e emissions this reduction in VMT will achieve. The impact of this measure was calculated by quantifying the difference between the 2005 interim disposal emissions (as calculated in the inventory) and the 2017 projected emissions. Emissions for 2017 were calculated using projected tonnage of disposal and applying the 2005 weighted average mileage to the interim disposal sites, assuming that contracts in place in 2005 would be the same as under full SWMP implementation by 2010. Gallons of diesel consumed were then calculated using the U.S. DOT calculation that estimates that one gallon of diesel moves one ton of solid waste 59 miles by truck, 202 miles by rail, and 514 miles by marine barge.[28] The annual distance for the marine barge portion of the trip from solid waste marine transfer stations to rail transfer stations was estimated to be 5 miles.[29] By 2017, this measure will result in an annual avoidance of approximately 187,000 metric tons of CO_2e each year.

3. Street Tree Planting Program

Assuming that street trees are planted at the same rate as they were from 1995-2006 (approximately 12,000 per year), the City is projected to plant more than 120,000 street trees between 2007 and 2017. A study completed for DPR estimated that each street tree in New York sequesters and avoids the emission of approximately 0.17 tons of CO_2 per year (due to carbon sequestration in the tree's biomass and through reducing the cooling needs of adjacent buildings).[30] Based on this calculation, street trees planted between 2006 and 2017 are expected to result in the annual sequestration and avoidance of approximately 21,000 metric tons of CO_2e by 2017

4. Purchase of Wind Power

Through the City's electricity agreement with the New York Power Authority (NYPA), the City will purchase 49,000 MWh of electricity annually produced by wind turbines every year beginning in 2008. This purchase represents approximately 1.3 percent of the total electricity consumed by the City in 2006.[31] This initiative is expected to result in an annual avoidance of the emission of more than 23,000 metric tons of CO_2e.

5. Local Law 86 of 2005

Local Law 86 of 2005 requires that new City buildings, and those undergoing significant renovation, be capable of achieving the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Silver rating (or an equivalent standard, so long as it is not less stringent than LEED). Because of this and additional energy efficiency requirements of the law, expected reductions in energy consumption by City buildings by 2017 were estimated by assuming that two-thirds of the City's increase in

[28] U.S. Department of Transportation Maritime Administration, *Environmental Advantages of Inland Barge Transportation*, August 1994.
[29] DSNY, SWMP FEIS.
[30] Center for Forest Systems Research, 2007.
[31] Wind percentage based on total 2006 electricity consumption of 3,737,696 MWh.

electricity use is due to new buildings coming on line (based on analyses of citywide buildings), and that buildings captured by Local Law 86 would use 25 percent less electricity than conventional buildings. Based on these assumptions, an annual avoidance of 69,000 metric tons of CO_2e is projected by 2017. Local Law 86 contains a requirement that energy savings for projects completed under the law be documented. As observed data become available, assessment of avoided CO_2e emissions will be adjusted as appropriate.

6. Local Law 119 of 2005

Local Law 119 of 2005 requires that the City purchase Energy Star appliances for use in its buildings when available. Future avoided CO_2e emissions were estimated by assuming that 20 percent of City buildings' electricity use is due to plug loads, and that a 20 percent reduction in this plug load through the use of Energy Star appliances was achievable.[32] Based on these conservative estimates, metric tons of CO_2e avoided are projected to be approximately 100,000 per year by 2017. As with Local Law 86, when observed data become available these estimates will be adjusted as appropriate.

[32] New York City Mayor's Office of Long-term Planning and Sustainability estimate.

CONCLUSION

Global climate change caused by an increase in the concentration of atmospheric greenhouse gases is one of the greatest challenges facing New York City. Potential climate change impacts include increased temperatures, changing precipitation patterns, more frequent and destructive storms, and rising sea levels. Acting now to reduce New York's contribution to this global crisis is of critical importance.

Citywide greenhouse gas emissions have increased by 8 percent since 1995, and are on trend to increase another 25 percent, or by 15 million metric tons, by 2030. To reach the City's goal of a 30 percent reduction below 2005 levels by 2030, this trend must first be overcome. The City's plans to overcome this trend and to achieve its reduction target will be detailed in PlaNYC.

Due to actions taken by the City, greenhouse gases from City government operations have stabilized since 2001 and are projected to remain stable through 2017. To match the City's overall 30 percent reduction target, the City government must augment planned measures and develop new reduction strategies. Some of these new strategies will be incorporated in PlaNYC.

Together, City government and the private sector will need to work together to achieve the City's reduction target. Collective action within the City will allow New York to not only meet its target but will also demonstrate to the world the power of collaboration in achieving greenhouse gas reduction goals.

This greenhouse gas emissions inventory completes an important first step in New York City's greenhouse gas reduction plans. By developing a clear understanding of the sources of the City's emissions, the trends the City has experienced, and the effectiveness of emissions reduction measures implemented by City government, the City will able to develop its plan to achieve its reduction target. While this report completes an important milestone, it is just the beginning of a long process.

To allow the City to monitor its progress toward achieving its reduction target, it is necessary to institutionalize the inventory process. By developing and implementing data compilation and analysis protocols, the City will be able to complete annual updates to its inventory. The City will also work to develop the infrastructure necessary to allow for ease of data reporting and analysis, both internally for City agencies, and externally for utilities and other entities. In addition, the City will collaborate with other cities around the country and the world to share analytical techniques and methodologies, with the goal of ensuring consistency in approaches used to quantify and report greenhouse gas emissions.

APPENDICES

APPENDIX A – EMISSIONS COEFFICIENTS CALCULATIONS

Emission Factor – Average Grid Electricity

This emission factor specifies the emissions per kilowatt-hour of the annual average kilowatt-hour produced in the electricity region specified. The average grid electricity emission factor is the average of emissions generated per kilowatt-hour over an entire year, taking into account fuels used and generating and emission control technologies in use in each plant. Because it is difficult, if not impossible, to know when electricity consumption quantified in the inventory occurred, the average grid electricity emission factor was used in developing the inventory and in quantifying emission reductions from measures. This factor provides the most accurate estimate of emissions generated from normal use of electricity.

Emission factors for both the government and citywide inventories measures analysis for all years were based on a best available estimate of the composition of New York City's power supply. Data for 07/2005-06/2006 were developed by a consultant to the City from Energy Velocity, a comprehensive database with unit-level data on capacity, generation, heat rate, and fuel(s) used. The city's CO_2 footprint was assessed by looking at each of the three sources of New York City power:

(1) in-city generation
(2) bilateral contracts between ConEd/NYPA and upstate generators
(3) other imports from upstate NY and PJM.

For in-city generation, it was estimated that approximately 30 GW were produced corresponding to approximately 20 million tons of CO_2.

For bilateral contracts, each plant outside Zone J that has an existing contract with NYPA or Con Edison was counted. As with the in-city sources, estimated electricity generated (using information for the capacity contracted at each plant) was divided into total CO_2 emission produced. The power provided by these contracts was reduced by 8 percent to account for transmission and distribution losses.

For other imports, several assumptions were made. First, total kWh of other imports was assumed to fill the difference between demand and other two categories, calculated as overall electricity consumed in NYC (from NYISO gold book) less in-city generation and less bilateral contracts. Second, since NYISO has a contract with PJM under which NYISO supplies power to PJM network upstate and PJM passes the same amount of power to NYC, it was assumed that PJM imports to NYC carry upstate NY emission profile. Third, it was assumed that all clean capacity in upstate NY is contracted to various players, and therefore NYC imports (excl. contracts) come from non-renewable upstate NY sources - coal, gas, and oil power plants. Finally, the CO_2 intensity of upstate non-renewable electricity was increased by 8 percent to account for transmission and distribution losses.

The three categories were combined and a weighted average was used as the New York City grid average:

	Generation	Emissions	CO_2/MWh
	GWh	short tons	lbs
In-city	29,900	20,171,470	1,349
Contract	16,804	1,884,703	224
Imported	5,572	5,062,667	1,817
	52,276		**1,038**

This coefficient was used for both municipal government operations and the citywide inventory for all years inventoried. Potential future changes in the average electricity mix are not accounted for in the forecasts. For historic years, it was clear that adequate data were not available to conduct this analysis and it was deemed better to show no change rather than to employ a different methodology. While PlaNYC includes electricity supply measures and New York State has established a renewable portfolio standard, it was determined that it would be best to account for these as greenhouse gas reduction measures, tracked independently of the forecast. The decision to count government electricity the same as that used citywide, despite having a New York Power Authority contract which can be traced to a specific mix, was made to better account for the impacts of marginal decisions within an interconnected grid. The exception to this approach of considering all electricity in New York City essentially equal would be the purchase of certified renewable energy credits, which guarantee a chain of custody and that are intended to inspire the development of new renewable resources.

Finally, it is important to single out the assumption that nuclear power is emissions free. Indian Point light water reactor is a significant source of electricity for New York City. Counting this source as having zero emissions has a sizable impact on the coefficient and on the entire city's profile. While it is undisputed that there are no carbon dioxide emissions generated during the fission reaction itself, there is a significant amount of energy utilized in the mining, processing and enrichment of the uranium fuel used. Moreover, it is considered probable that over the next several decades these “upstream” energy costs associated with uranium fuel will increase significantly on a per-unit of fuel basis.

Emission Factor – Steam at Delivery

To account for and accurately apportion the carbon dioxide emissions associated with the production and distribution of steam, it was necessary to establish a coefficient. Due to high transmission and generation losses, it was important to distinguish between generation and supply. The usage data that was available was based on metered supply. Therefore a coefficient to covert metered steam – measured in pounds – to Btu. Steam is released from Con Edison’s plants at 125 pounds per square inch (psi). At this pressure, it is at 1193 Btu per pound. Because the steam is reduced in quantity by 14 percent, on average, during delivery, for each pound purchased, 1.16 pounds are produced. Con Edison estimates its steam boilers operate at 81 percent efficiency, on average. Water used to produce steam, delivered at 50 degrees F, on average, has a Btu content of 18 Btu per pound. Fuel consumption per pound of steam purchased, therefore, is determined through the formula (1193 Btu/pound – 18 Btu/pound) x 1.16/0.81, resulting in a conversion factor of 1,687 btu/pound.

Con Edison provided data on steam production facilities for the year 2006. 44 percent was a result of cogeneration, 18.6 percent was produced by heavy fuel oil and 37.7 percent was produced by natural gas. For purposes of this calculation it was assumed that emissions from cogeneration are zero because the total emissions from these plants are already accounted for in the electricity coefficient. The CO_2 per BTU of heavy fuel oil and natural gas were multiplied by the above percentages and a weighted average was produced. As generation and delivery inefficiencies are already accounted for in the pound to Btu conversion factor, the resultant weighted average coefficient of 76.478 pounds of CO_2 per MMBtu of steam was used for all years and in both the government and citywide inventories.

Emission Factor – Solid Waste Management

Waste Type	Disposal Technique	Emissions Unit	Per Waste Unit	CH_4 Coefficient	Sequestered At Site Coefficient
Paper Products	Managed Landfill	(tons)	(tons)	2.138262868	-0.927925396
Food Waste	Managed Landfill	(tons)	(tons)	1.210337473	-0.080689165
Plant Debris	Managed Landfill	(tons)	(tons)	0.685857901	-0.847236231
Wood/Textiles	Managed Landfill	(tons)	(tons)	0.605168736	-0.847236231
All Other Waste	Managed Landfill	(tons)	(tons)	0.000000000	0.000000000

Emission Factor – Transportation Energy Use – Average Technology

These emission factors specify both the average vehicle fuel efficiency and average emissions per mile of nitrous oxide and methane for particular classes of vehicles when using particular fuels (e.g. gasoline powered mid-size autos). Values are provided for each year from 1990 through 2020, based on historical and simulated future evolution of the on-road fleet in the U.S.

Further Details of the research provided by the Tellus Institute in the development of the CACP software emission factors:

Emission factors in the transportation sector are provided for light duty vehicles (i.e., passenger cars and light-duty trucks), heavy-duty vehicles, and rail for each major transportation fuel.

- For light and heavy-duty vehicles, emission factors are denominated in units of grams per vehicle mile traveled (grams/mile). Equivalent emission factors are also provided in units of pounds per million BTU (lbs/MMBtu).
- For rail, emission factors are denominated in units of lbs/MMBtu only.

Average emission factors for the existing fleet of vehicles depend on the likely mix of vehicle technologies, fuels, and age vintage. Criteria air pollutant emission factors, as well as nitrous oxide and methane emission factors depend not only on the amount and type of fuel consumed or avoided, but also on the technology characteristics, operational parameters, and emission control equipment of vehicles. Carbon dioxide emission factors are more straightforward as they depend only on the amount and type of fuel consumed or avoided.

Average emission factors (N_2O, CH_4) for new vehicles depend on fuel type and the regulatory standard to which they are certified. Carbon dioxide emission factors are more straightforward as they depend only on the amount and type of fuel consumed or avoided.

Sources
The transport sector emission factors were derived from a variety of sources, as follows:

1. On-highway vehicle miles traveled (VMT) in 1990 and 1999: This data is from the Annex D of USEPA (2001a).
2. On-highway vehicle miles traveled and fleet average fuel economy for the years 2000 through 2020: National Energy Modeling System (NEMS) output for the reference case (USEIA, 2001)

3. Emissions Standards are from published USEPA federal and California-specific tailpipe standards (USEPA, 2000).
4. Off-road (rail) emission factors are from published USEPA emission factors for locomotives (USEPA, 1997).
5. Greenhouse Gas Emissions and Fuel Use Data are from the USEPA's national greenhouse gas inventory (USEPA, 2001a).
6. On-Road Stock Turnover Values are from Oak Ridge National Laboratory's transportation data book (Davis, 2001).
7. VMT Data Determination Methodology is from the USEPA (2001d).
8. IPCC GHG emission inventory guidelines are from IPCC (1996)
9. On-road deterioration rates for light duty vehicles and heavy trucks for criteria air pollutants are from USEPA (2001e).

Assumptions
To determine baseline fleet-wide emission factors, the following simplifying assumptions were made:
1. VMT per year per age vintage is assumed constant. In other words, old and new cars alike are presumed to drive the same number of miles per year.
2. The model also assumes that the stock turnover and deterioration rates stay constant with time. In reality, economic factors and quality improvements may cause these rates to change.

The approach used to determine historical emission factors for the years 1990 and 1999 is described below.

N_2O and CH_4: gm/mile
Historic emission factors (gm/mile) for the above pollutants were determined for the years 1990 and 1999 using a three-step process (based on USEPA, 2001a), as outlined below:

1. Identify the VMT profile by vehicle age (years) and fuel type for highway vehicles of each age, from one to twenty-five years old.
2. Identify control technology shares (% of VMT) within and outside California (see tables below). These assignments are separated between California standards and rest-of-country standards for cars and light trucks. For example, gas cars made between 1980 and 1982 are assigned to non-catalyst, oxidation, or Tier 0 technology controls as shown on the excerpt in the table below.

<u>Excerpt from Control Technology Assignments Worksheet (USEPA, 2001a)</u>

Model Year	Non-catalyst	Oxidation	Tier 0	Tier 1	LEV	Total
1980	5%	88%	7%	0	0	100%
1981	0	15%	85%	0	0	100%
1982	0	14%	86%	0	0	100%

3. Identify average N_2O and CH_4 emission factor for each control technology (gm N_2O per km and gm CH_4 per km) and convert to gm of each pollutant per mile.
4. Combine N_2O and CH_4 emission factor for each control technology to compute an adjusted emission factor for each vehicle model year, as follows:
   Where:
   - EFMY is the adjusted emission factor for that model year (MY)
   - Controlk = control technology assignment portion,
   - k = range of control technology options (in the example above, k would be the set: {non-catalyst, oxidation, tier 0})
     - EFk = emission factor for control technology type k
5. Calculate weighted average emission factor across all years and control technology shares for each vehicle class (nation, California, non-California) as per the following formula:
   Where:
   - MY = model year
   - k = present year (year for which one is determining the fleet average emission factor)
   - EFMY = adjusted emission factor for a certain model year
   - ti = percentage of VMT in cars of age (i)

N_2O and CH_4: lb/mmbtu
To convert emission factors from units of grams per mile to units of lbs/mmbtu, average fleet fuel economy by vehicle class was multiplied by emission factors (in grams per mile), and appropriate conversion factors applied.
CO_2: lb/mmbtu
Carbon dioxide emission factors by fuel type was obtained from the IPCC (1996) in units of tonnes carbon per TJ, and converted to lb CO2/mmbtu by applying appropriate conversion factors.
CO_2: gm/mile
Carbon dioxide emission factors in units of lb CO2/mmbtu were converted to units of gm/mile by dividing by average fleet fuel economy by vehicle class.

Fuel	Vehicle Type	Year	Coefficient (grams per mile)		Fuel Efficiency (miles per gge*)
			N_2O	CH_4	
CNG	Auto - Mid-Size	ALL	0.028000000	0.032500000	27.200000000
Diesel	Heavy Truck	1995	0.048667635	0.076950068	5.480254080
Diesel	Heavy Truck	2001	0.048270664	0.071509591	5.623161600
Diesel	Heavy Truck	2006	0.048270664	0.067426686	5.474883456
Diesel	Heavy Truck	2017	0.048270664	0.064760003	5.482423296
Diesel	Marine	ALL	2.694238323	8.419494759	0.090000000
Diesel (ULSD)	Heavy Truck	1995	0.048667635	0.076950068	5.480254080
Diesel (ULSD)	Heavy Truck	2001	0.048270664	0.071509591	5.623161600
Diesel (ULSD)	Heavy Truck	2006	0.048270664	0.067426686	5.490986054
Diesel (ULSD)	Heavy Truck	2017	0.048270664	0.064760003	5.498548070
Diesel (ULSD)	Marine	ALL	2.694238323	8.419494759	0.090000000
Diesel	Rail - Commuter	1995	0.073238262	0.22886957	3.630000000
Diesel	Rail - Commuter	2001	0.068341079	0.213565872	3.548106831
Diesel	Rail - Commuter	2006	0.066668395	0.208338735	3.637127432
Diesel	Rail - Commuter	2017	0.063136295	0.197300921	3.840603093
Diesel	Transit Bus	1995	0.048667635	0.076950068	5.480254080
Diesel	Transit Bus	2001	0.048270664	0.071509591	5.623161600
Diesel	Transit Bus	2006	0.048270664	0.067426686	5.635909440
Diesel	Transit Bus	2017	0.048270664	0.064760003	5.643671040
Electricity	Passenger Vehicle	ALL	NA	NA	82.000000000
Ethanol (E-85)	Auto - Mid-Size	ALL	0.02800000	0.12600000	27.200000000
Gasoline	Motorcycle	1995	0.008010188	0.344733555	20.932800000
Gasoline	Motorcycle	2001	0.007081371	0.244111735	24.656204160
Gasoline	Motorcycle	2006	0.00683128	0.21701843	25.234913760
Gasoline	Motorcycle	2017	0.00675925	0.20921472	25.401600000
Gasoline	Light Truck/SUV/Pickup	1995	0.09597047	0.10426235	11.516014300
Gasoline	Light Truck/SUV/Pickup	2001	0.08384426	0.07682242	13.176956710
Gasoline	Light Truck/SUV/Pickup	2006	0.07069350	0.06307822	13.799511660
Gasoline	Light Truck/SUV/Pickup	2017	0.06475013	0.05685341	14.081153650
Gasoline	Auto - Mid-Size	1995	0.06805646	0.06678030	18.373351470
Gasoline	Auto - Mid-Size	2001	0.05984134	0.05531701	19.202507466
Gasoline	Auto - Mid-Size	2006	0.05073737	0.05033869	20.155636146
Gasoline	Auto - Mid-Size	2017	0.04622726	0.04823057	22.252519242
Gasoline	Auto - Full-size (taxi)	1995	0.06805646	0.06678030	13.000000000
Gasoline	Auto - Full-size (taxi)	2001	0.05984134	0.05531701	13.000000000
Gasoline	Auto - Full-size (taxi)	2006	0.05073737	0.05033869	13.000000000
Gasoline	Auto - Full-size (taxi)	2017	0.04622726	0.04823057	13.000000000
Gasoline	Passenger Vehicle	1995	0.07925500	0.08181700	17.300000000
Gasoline	Passenger Vehicle	2001	0.07033900	0.06472200	17.600000000
Gasoline	Passenger Vehicle	2006	0.06028600	0.05643400	17.600000000
Gasoline	Passenger Vehicle	2017	0.05644300	0.05298600	18.200000000
Methanol (M-85)	Auto - Mid-Size	ALL	0.02800000	0.06500000	27.200000000

***gallons of gasoline equivalent**

Emission Factor – Carbon Dioxide from Fuel Use

These factors specify the carbon dioxide emissions from fuel use. These are standard factors and do not vary significantly with either combustion or mitigation technology, only with type of fuel burned.

The CACP software contains only one value for the emissions of carbon dioxide for any particular fuel, but within this constraint the default values have been selected to be consistent with government information sources in the U.S. The main source for carbon dioxide (CO_2) emission coefficients was the 1605 Voluntary GHG Emissions Reporting Guidelines produced by the DOE (http://www.eia.doe.gov/oiaf/1605/ggrpt/, 2001). For fuels for which U.S. values were not readily available, the primary source was the IPCC default emission factors supplied in the 1996 Revised Reporting Guidelines on Greenhouse Gas Emissions.

Fuel	Emissions Unit	Per Energy Unit	CO_2 Coefficient
CNG	(lbs)	(cubic feet)	0.1257263756440
Coal	(lbs)	(tons)	4141.83600000000
Diesel	(lbs)	(US gal)	20.9680772531510
Diesel (ULSD)	(lbs)	(US gal)	21.0297480686018
Ethanol (E-85)	(lbs)	(US gal)	11.0523447878980
Gasoline	(lbs)	(US gal)	20.7085424276427
Green Electricity	(lbs)	(kWh)	0.0000000000000
Heavy Fuel Oil	(lbs)	(US gal)	27.5841290108120
Light Fuel Oil	(lbs)	(US gal)	23.0101406551437
Methanol (M-85)	(lbs)	(US gal)	9.5413730577200
Natural Gas	(lbs)	(therms)	12.3248104900883
Sewage Gas	(lbs)	(therms)	0.0000000000000
Solar	(lbs)	(kWh)	0.0000000000000

Emission Factors – Residential, Commercial, and Industrial Energy Use – Average Technology

These emissions factors represent the typical emissions of air pollutants associated with the burning of the fuels listed. In some cases, the emission factors vary by sector (e.g. emissions for fuel oil are different in the industrial than the residential sector). These average emission factors can be used as defaults throughout the residential, commercial and industrial sectors for both inventory and measures analysis, and they are recommended for use in the analysis modules.

Sources
There are several sources used to develop RCI emission factors:
1. Fuel consumption for 1990: National Energy Modeling System (NEMS) internal data (USEIA, 2001a).
2. Fuel consumption for the years 1999 through 2020: National Energy Modeling System (NEMS) output for the reference case (USEIA, 2001).
3. Greenhouse gas emission factors by fuel type are taken from IPCC, 1996.

Assumptions
1. The EPA and EIA use the same classification guidelines to determine sector-based characteristics (i.e. the two databases define which energy uses and correlated emissions fall into "residential," "commercial," and "industrial" sectors in the same manner).
2. Emission factors calculated for 1999 are presumed to hold true through 2020.

Baseline (1990, 1999-2020) Emission Factors

CO_2, CH_4, and N_2O: lb/MMBtu
IPCC (1996) GHG emission factors for each sector were converted from units of kg/TJ to lb/mmbtu and applied to 1990 and 1999 through 2020.

			Coefficient	
Fuel	Emissions Unit	Per Energy Unit	N_2O	CH_4
Coal	(lbs)	(tons)	0.062566538584	0.446903860752
Heavy Fuel Oil	(lbs)	(US gal)	0.000210347215	0.001009845571
Light Fuel Oil	(lbs)	(US gal)	0.000195322414	0.003255373334
Natural Gas	(lbs)	(therms)	0.000023259800	0.001162988200
Sewage Gas	(lbs)	(therms)	0.000000000000	0.001162988200

APPENDIX B – GLOSSARY

Base Year: The year for which the CCP member conducts its emissions inventory. For New York City, the base year for the Citywide Inventory is 2005. For the Government Inventory, the base year is Fiscal Year 2006, which began on July 1, 2005 and ended on June 30, 2006.

Background Year: Years used to determine the trends registered in greenhouse gas emissions prior to the base year. For the Citywide Inventory, the background years are 1995 and 2000. For the Government Inventory, the background year is Fiscal Year 2001.

Carbon Dioxide (CO_2): Carbon dioxide is essential to living systems and is released by animal respiration, decay of organic matter, and fossil fuel burning. It is removed from the atmosphere by photosynthesis in green plants. The concentration of CO_2 in the atmosphere has increased by about 30 percent since the burning of coal and oil began on a large scale.

Carbon dioxide equivalent (CO_2e): CO_2e is a unit that allows emissions of greenhouse gases of different strengths to be added together or compared. For carbon dioxide itself, emissions in tons of CO_2 and tons of CO_2e are the same thing, whereas for methane, an example of a stronger greenhouse gas, one ton of methane emissions has the same potential effect on global climate change as 21 tons of CO_2. Thus, one ton of methane emissions can be expressed as 21 tons of CO_2e. One ton of nitrous oxide (N_2O) has the same potential effect on global climate change as 310 tons of CO_2.[33]

Chlorofluorocarbons (CFCs): Chlorofluorocarbons are carbon compounds that also contain some chlorine and some fluorine. CFCs do not occur naturally: they are synthetic products used in various industrial processes and also as propellant gas for sprays. CFCs are typically used in refrigerants, solvents, foam-makers, and for use in aerosol sprays. CFCs are significant contributors to ozone depletion and also contribute to global climate change.

Cities for Climate Protection® (CCP) Campaign: A campaign of ICLEI – Local Governments for Sustainability, CCP is a performance-oriented campaign that offers a framework for local governments to develop a strategic agenda to reduce global climate change and air pollution emissions, with the benefit of improving community livability. The over 750 local governments participating in the Campaign represent 15 percent of global greenhouse gas emissions.

[33] Although the Intergovernmental Panel on Climate Change (IPCC) revised the global warming potential of methane and nitrous oxide in 2001 with the release of the Third Assessment Report (23 for methane and 296 for nitrous oxide), international practice is to use the global warming potential for these gases from the IPCC's Second Assessment Report (1996). Those values are what are used by countries that are parties to the Kyoto Protocol and are what current trading mechanisms and registries (e.g. California Climate Action Registry) are based on.

Clean Air and Climate Protection (CACP) Software: Developed by the State and Territorial Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO), ICLEI, and Torrie Smith Associates Inc., a software developer from Toronto, Canada for CCP members, the computer software allows local governments to analyze and organize data from communities and from the local government operations. The software translates data on energy use and solid waste disposal into greenhouse gas emissions and quantifies the greenhouse gas emissions reduction of potential programs and actions.

Greenhouse Effect: The greenhouse effect refers to the increasing warming of the earth because of gases in the atmosphere that trap the sun's energy on earth. In other words, the sun's energy passes through to the earth, but more energy than usual is prevented from escaping back into space. This energy remains trapped on earth and gradually warms the earth beyond its normal temperature. The earth's climate is determined by a balance between the solar energy that arrives from space and the heat energy that the earth creates from the sun's rays. Atmospheric greenhouse gases such as water vapor, carbon dioxide, methane, and nitrous oxide naturally present in the atmosphere in small amounts trap some of the outgoing energy, retaining heat like the glass panels of a greenhouse. The earth normally stays at a constant temperature by shedding heat into space at the same rate it absorbs the energy from the sun. However, problems arise when the atmospheric concentration of greenhouse gases increases and traps heat within the atmosphere.

ICLEI – Local Governments for Sustainability: An international environmental organization serving local governments. Its mission is to build and serve a worldwide movement of local governments to achieve tangible improvements in global environmental conditions and sustainable development through cumulative local actions. ICLEI serves as an information clearinghouse on sustainable development by providing policy guidance, training and technical assistance, and consultancy services to increase local governments' capacity to address global challenges. The Cities for Climate Protection Campaign is one of several ICLEI programs.

Methane (CH_4): Methane is produced by anaerobic decomposition of solid waste in landfills, sewage treatment facilities, and wetlands; as a byproduct of fossil fuel energy production and transport; and outgassing from livestock. It is also the principal constituent of natural gas, can leak from natural gas production and distribution systems, and is emitted in the process of coal mining. One ton of methane has the same potential effect on global climate change as 21 tons of CO_2.

Nitrous Oxide (N_2O): Nitrous oxide is produced through the combustion of fossil fuels and through the production and application of fertilizer used for agriculture. One ton of nitrous oxide has the same potential effect on global climate change as 310 tons of CO_2.

APPENDIX C – REFERENCES

City of New York

City of New York
Mayor's Office of Operations
Office of Long-Term Planning and Sustainability
253 Broadway, 10th floor
New York, NY 10007
www.nyc.gov/planyc2030

Cities for Climate Protection (CCP):

ICLEI – Local Governments for Sustainability
U.S. Office
436 14th Street, Suite 1520
Oakland, CA 94612
(510) 844-0699
iclei-usa@iclei.org
http://www.iclei.org/us

Clean Air and Climate Protection (CACP) Software:

Torrie Smith Associates, Inc.
95 Beach Street, Unit 108
Ottawa, Ontario, K1S 3J7, Canada
(613) 238-3045
info@torriesmith.com
http://www.torriesmith.com

The National Association of Clean Air Agencies (NACAA)
444 North Capitol Street, N.W.
Suite 307
Washington, D.C. 20001
(202) 624-7864
http://www.4cleanair.org

Climate Change Impacts:

Rosenzweig, C. and W.D. Solecki (Eds). 2001. Climate Change and a Global City: The Potential Consequences of Climate Variability and Change—Metro East Coast. Report for the U.S. Global Change Research Program, National Assessment of the Potential Consequences of Climate Variability and Change for the United States, Columbia Earth Institute, New York. 224 pp.

United States Environmental Protection Agency. *Climate Change and New York.* 1997. Available from http://yosemite.epa.gov/oar/globalwarming.nsf

<u>Citywide Inventory</u>

Residential, Commercial, Institutional, and Industrial Sectors:

Con Edison
www.coned.com

KeySpan Energy
www.keyspanenergy.com

New York City Economic Development Corporation (EDC)
110 William St.
New York, NY 10038
www.nycedc.com

Petroleum Infrastructure Study. Prepared by ICF Consulting for the New York State Energy and Research Development Authority. 2006. Available online at http://www.nyserda.org/Energy_Information/PetroleumInfrastructureStudy.pdf

Transportation Sector:

New York Metropolitan Transportation Council
199 Water Street
New York, NY 10038
www.nymtc.org

Metropolitan Transportation Authority (MTA)
347 Madison Avenue
New York, NY 10017
www.mta.info

MTA Long Island Rail Road
Jamaica Station
Jamaica, NY 11435
www.mta.info/lirr

MTA. Metro-North Rail Road
347 Madison Avenue
New York, NY 10017
www.mta.info/mnr

MTA New York City Transit
370 Jay Street
Brooklyn, NY 11201
www.mta.info/nyct

Port Authority Trans-Hudson Corporation (PATH)
255 Park Avenue South
New York, NY 10003
www.panynj.gov/path

Waste Sector:

City of New York – Mayor's Management Reports (Fiscal Years 1995, 1997, 1999, 2001, 2006) – New York City Mayor's Office of Operations http://www.nyc.gov/html/ops/html/home/home.shtml

Preliminary Waste Characterization Study. Prepared by R.W. Beck for the New York City Department of Sanitation. 2004. Available online at http://www.nyc.gov/html/dsny/downloads/pdf/pubnrpts/swmp-4oct/appendix-d.pdf

Commercial Waste Management Study Volumes I and II. Prepared by Henningson, Durham & Richardson Architecture and Engineering, PC. for the New York City Department of Sanitation. 2004. Available online at http://www.nyc.gov/html/dsny/html/reports/cwms-ces.shtml

Aviation: Port Authority of New York and New Jersey
255 Park Avenue South
New York, NY 10003
www.panynj.gov

Shipping: *Estimating Transportation Related Greenhouse Gas Emissions and Energy Use in New York State.* Prepared by ICF Consulting for the Department of Transportation's Center for Climate Change and Environmental Forecasting. 2005. Available online at http://climate.volpe.dot.gov/docs/nys.pdf

Government Inventory

Buildings Sector: New York City Department of Citywide Administrative Services
Office of Energy Conservation
Municipal Building, 1 Centre Street, 16th Floor
New York, NY 10007
http://www.nyc.gov/html/dcas/html/resources/dcas_oec.shtml

Sewage and Water Sector: New York City Department of Citywide Administrative Services
Office of Energy Conservation
Municipal Building, 1 Centre Street, 16th Floor
New York, NY 10007
http://www.nyc.gov/html/dcas/html/resources/dcas_oec.shtml

New York City Department of Environmental Protection
59-17 Junction Blvd.
Flushing, NY 11373
www.nyc.gov/dep

Streetlights Sector: New York City Department of Citywide Administrative Services
Office of Energy Conservation
Municipal Building, 1 Centre Street, 16th Floor
New York, NY 10007
http://www.nyc.gov/html/dcas/html/resources/dcas_oec.shtml

Vehicle Fleet Sector: New York City Department of Citywide Administrative Services
Office of Fleet Administration
Municipal Building, 1 Centre Street, 18th Floor
New York, NY 10007
http://www.nyc.gov/html/dcas/html/resources/dcas_oec.shtml

New York City Office of Management and Budget
75 Park Place
New York, NY 10007
www.nyc.gov/omb

Waste Sector: New York City Department of Sanitation
125 Worth Street
New York, NY 10013
www.nyc.gov/dsny

New York State Department of Environmental Conservation, Division of Solid Waste & Hazardous Materials (1999). *New York State Recycling Bulletin 1999 Edition.* Available online at www.dec.state.ny.us/website/dshm/redrecy/bulletin99.pdf

City of New York – Mayor's Management Reports (Fiscal Years 1995, 2001, 2006) – New York City Mayor's Office of Operations
http://www.nyc.gov/html/ops/html/home/home.shtml

APPENDIX D – ACRONYM DEFINITIONS

The following acronyms are used throughout this report.

New York City agencies

DCAS – New York City Department of Citywide Administrative Services
DEP – New York City Department of Environmental Protection
DDC – New York City Department of Design and Construction
DJJ – New York City Department of Juvenile Justice
DOB – New York City Department of Buildings
DOHMH – New York City Department of Health and Mental Hygiene
DOT – New York City Department of Transportation
DPR – New York City Department of Parks and Recreation
DOC – New York City Department of Correction
DOE – New York City Department of Education
DSNY – New York City Department of Sanitation
FDNY – New York City Fire Department
HRA – New York City Human Resources Administration
NYPD – New York City Police Department

Other Entities

CUNY – City University of New York
EDC – New York City Economic Development Corporation
FHWA – Federal Highway Administration
HHC – New York City Health and Hospitals Corporation
LIPA – Long Island Power Authority
LIRR – Long Island Rail Road
MTA – Metropolitan Transportation Authority
MNR – Metro North Rail Road
NYDEC – New York State Department of Environmental Conservation
NYMTC – New York Metropolitan Transportation Council
NYPA – New York Power Authority
PATH – Port Authority Trans-Hudson Corporation
SCA – New York City School Construction Authority
USDOT – United States Department of Transportation
USEPA – United States Environmental Protection Agency

All calculations presented in this report are based on data submitted to the New York City Mayor's Office. While every effort has been made to ensure these data's accuracy, the possibility for errors exists. This report is not intended to be a flawless accounting of New York City's carbon emissions, but is rather intended to provide guidance from which policy decisions may be based. The City of New York does not accept responsibility for the completeness or accuracy of this report, and it shall not be held liable for any damage or loss that may result, either directly or indirectly, as a result of its use.