Energy Conservation Steering Committee

Long-Term Plan to Reduce Energy Consumption and Greenhouse Gas Emissions of Municipal Buildings and Operations



PlaNYC

July 2008

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THE CITY OF NEW YORK
OFFICE OF THE MAYOR
NEW YORK, N.Y. 10007

EDWARD SKYLER
DEPUTY MAYOR FOR OPERATIONS

MEMORANDUM

To: Mayor Michael R. Bloomberg

From: Edward Skyler
Chair, Energy Conservation Steering Committee

Date: July 7, 2008

Subject: Long-Term Action Plan for Reducing Energy Consumption and Greenhouse Gas Emissions of the City of New York's Municipal Buildings and Operations

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1. Overview

The municipal government of the City of New York (City) produces approximately 3.8 million metric tons of greenhouse gas (GHG) emissions per year and consumes about 6.5% of New York City's total energy usage. As a result, in Fiscal Year 2009 (FY'09), the City will spend roughly $1 billion on energy costs for its buildings and operations. Given the magnitude of these environmental and financial impacts, on October 22, 2007, you signed Executive Order 109 and established the Energy Conservation Steering Committee (Steering Committee). The Steering Committee was charged with developing and implementing a long-term action plan (Plan) to reduce the energy consumption and GHG emissions of the City's municipal buildings and operations by 30% by 2017, thus advancing a key PlaNYC energy initiative. In addition, you made an annual commitment equal to 10% of the City's energy budget toward this effort, which we expect to exceed $900 million over the next nine years.[1] The City allocated $80 million in FY'08 to implement the short-term action plan issued last December.

The Steering Committee includes the Office of Operations/Long-Term Planning and Sustainability (OLTPS), Office of Management and Budget (OMB), New York City Economic Development Corporation (EDC), Department of Design and Construction

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[1] The $900 million commitment assumed over the next nine years is based on the FY'09 budget allocation of $100 million, 10% of the City's $1billion energy budget for FY'09.

(DDC), and Department of Citywide Administrative Services (DCAS). Earlier this year, we enlisted a technical advisory team comprised of the energy consulting firms AECOM Technology Corp. and KEMA, Inc., to conduct extensive research, interviews, and analysis on the various reduction opportunities available to the City and their relative cost-effectiveness.

In short, our research and analysis over the last few months have produced the following key findings:

- The City must achieve a reduction of 1.68 million metric tons of carbon dioxide equivalents (CO_2e) annually to meet its 30% reduction goal by 2017;

- We can successfully meet our 30% GHG reduction goal by 2017 through the implementation of an aggressive capital improvement program for the City's facilities, and significant enhancements to its current operations and maintenance (O&M) practice;

- Upgrades to existing buildings provide the largest opportunity for reduction, 57% of the total;

- The Plan will require an estimated $2.3 billion investment over the next nine years, of which over $900 million has already been committed by the City, and we will identify the additional required funding from the full range of available sources, including state and federal programs, and private grants;

- Through the implementation of the Plan, the City is expected to break even on its investment in FY'13 on an annual cash flow basis, and in FY'15 on a cumulative basis; and

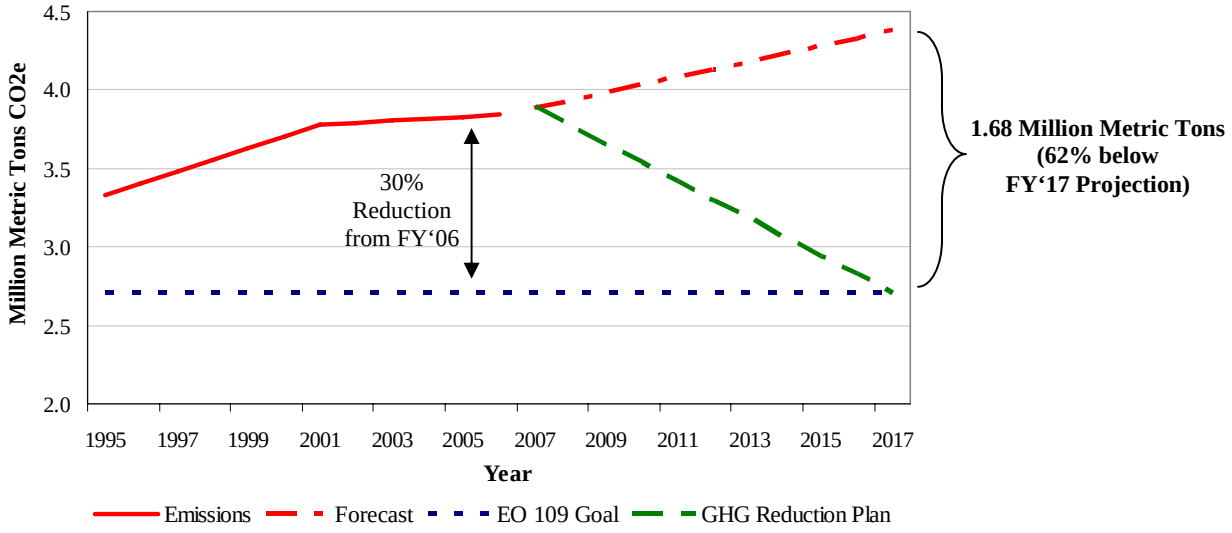
- The overall project portfolio identified has an average payback (implementation cost divided by annual bill savings) of 7.6 years, equaling a return on investment of approximately 13% per year.

2. Long-Term Action Plan

A. Reduction Target

Executive Order 109, and Local Law 22 of 2008 which followed, set the GHG emissions levels of FY'06 as the baseline for the City's reduction goal. The GHG emissions inventory completed by OLTPS in April 2007 established the FY'06 levels at 3.8 million metric tons of CO_2e. Given the baseline, and accounting for a 1.2% annual increase in GHG emissions expected over the next nine years, we estimate that the City must achieve and maintain a reduction of 1.68 million metric tons of CO_2e annually by 2017 to meet its goal, over 60% below the current FY'17 projection. Figure 1 below illustrates these statistics.

Figure 1: Projected CO2e Emissions for City Government



B. Reduction Principles

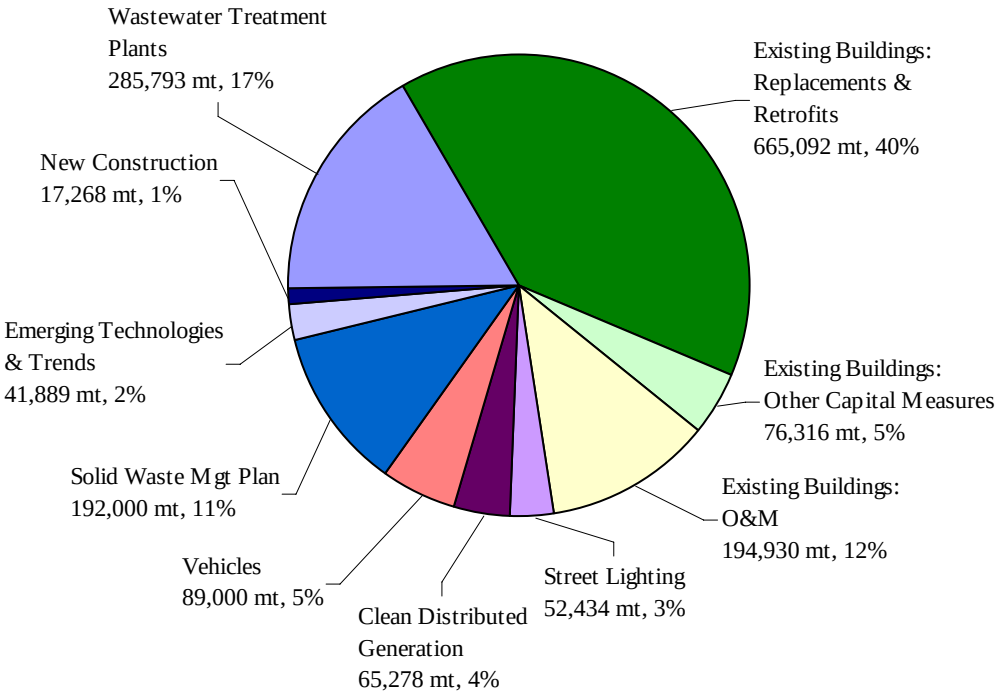
In developing our Plan, the Steering Committee applied the following guiding principles:

- Focus on efficiency projects using currently-available, proven technologies and strategies to the maximum extent possible;
- Adjust for real resource constraints (e.g., operational, financial) limiting the scale and scope of projects to be considered;
- Incorporate best practices into operations and maintenance activities to ensure the appropriate use of existing equipment and new capital improvements;
- Analyze the financial impacts of implementation, including capital improvements, operating costs, and the extent to which these investments are expected to generate energy bill savings; and
- Coordinate and enhance existing energy conservation programs across the City.

C. Reduction Strategy

Based on these criteria, the Steering Committee has identified a broad range of GHG reduction measures, ranging from building-specific energy efficiency projects, such as boiler upgrades and lighting retrofits, to methane capture projects at wastewater treatment plants, to improvements in facility operations and maintenance (O&M) programs. Figure 2 below provides further detail on each group of energy efficiency projects that we identified.

Figure 2: Potential for Annual Greenhouse Gas Reductions by Project Group
1.68 million metric tons (mt) per year



Although City agencies are already undertaking many of these types of projects, it is clear that the City needs to significantly expand its project management activities and committed resources to realize the full energy saving potential of these opportunities and achieve its GHG reduction goal. By FY'17, the City will need to complete about 2,200 projects across the groups shown above, or roughly 10 times the number of projects completed over the last 10 years.[2] Below is a brief description for each project group shown in Figure 2 above.

C.1. Reduction Opportunities

- *Existing Buildings*

  Improvements to the City's existing building portfolio (e.g., firehouses, police precincts, sanitation garages, offices, and courthouses) account for more than half of the GHG reduction opportunities identified.

  - *Replacements and Retrofits*
    This group of projects offers the greatest opportunity for reduction, accounting for approximately 40% of the GHG reduction potential. Projects include upgrading facility lighting, refrigeration units, office equipment, and heating, ventilating, and air conditioning (HVAC) systems. Building energy audits assist in identifying these opportunities.

[2] The City completed 278 projects through the New York Power Authority's (NYPA) Energy Cost Reduction Program, with an inflation-adjusted value of $306 million from January 1998 to December 2007.

- *Other Capital Projects*
  This group of projects includes the replacement of outdated oil boilers, data center equipment upgrades, and the installation of building management systems, which allow facility managers to control and optimize a facility's energy systems.

- *Operations & Maintenance (O&M)*
  This group of projects consists primarily of developing and implementing preventive practices in major energy-consuming buildings, including identification and correction of conditions that might lead to energy waste, such as leaking pipes, clogged steam traps, and inefficient air distribution, pumps, or fan systems. It also includes retrocommissioning, a process that systematically identifies the most wasteful inefficiencies that technicians can correct in a cost-effective manner to restore the building's original level of energy-efficient operation.

- *Wastewater Treatment Plants (WWTPs)*

  This group of projects offers the second largest opportunity for GHG reductions, accounting for approximately 17% of the total reduction potential. WWTPs decontaminate sewage and storm water runoff through a series of physical, chemical, and biological processes, and release the water back into the environment once it has been cleaned. These processes generate significant amounts of methane gas, one of the strongest GHG emissions sources. Projects in this group include fixing methane gas leaks, using recaptured methane to power electric generation equipment, and making general efficiency improvements to other specialized equipment.

- *Solid Waste Management Plan (SWMP)*

  The SWMP fundamentally restructures the handling of solid waste in the City. Enacted in 2006, the SWMP requires the City to build a rail- and barge-based network to replace long-haul trucking for waste disposal services. As a result, Sanitation trucks will travel approximately 2.7 million fewer miles per year, and travel by tractor-trailer trucks will be reduced by 3 million miles per year. These vehicle mile reductions will reduce GHG emissions by roughly 192,000 metric tons, or 11% of the total reduction potential.

- *Vehicles*

  The City maintains one of the largest municipal fleets in the country, including a variety of hybrid vehicles. The City will seek to improve its fleet by accelerating the purchase of more energy efficient vehicles, adopting best practices to economize vehicle miles traveled, and improving vehicular O&M programs.

- *Street Lighting*

  This group of projects includes the installation of more efficient street lighting throughout all five boroughs over the next three years.

- *Clean Distributed Generation*

  This group of projects consists of expanding on-site electricity generation at City facilities. Leading examples of this technology include solar panels and combined heat and power systems (also known as cogeneration). Candidates for clean distribution generation systems include a large number of the City's biggest facilities, which often operate on long daily schedules. The City recently released a RFP for two megawatts of solar power.

- *New Construction*

  This group of projects includes the implementation of more rigorous "green building" standards for new construction and major renovation projects, which will enable the City to exceed the standards set by Local Law 86 of 2005.

- *Emerging Technologies and Trends*

  This group of project consists of using advanced technologies that are continuing to become more readily available. Solar thermal energy, thermal scan technology, and green walls (vegetated grid-like structures that are attached to exterior building walls) are all examples. In addition, the improved efficiency of our electricity supply infrastructure is also expected to contribute to GHG reductions.

C.2. Reduction Activities

To implement the range of large-scale, diverse, and complex projects highlighted above, the City will need to pursue the following 10 key activities:

- Follow a structured approach to implementing projects that balances the acceleration of simple, cost-effective projects with the need to begin more advanced initiatives which require longer lead times;

- Enhance project management capacity at agencies by: (i) providing additional staff where necessary, (ii) strengthening centralized support for agencies, (iii) developing guidance documents and analysis tools for agency staff, and (iv) offering additional training on available technologies and best practices;

- Develop and implement standardized O&M protocols for facilities management and vehicle use, including a detailed review of agency contracting processes and staffing needs;

- Explore advanced metering and monitoring technologies for installation in major energy-consuming buildings to optimize O&M practices and identify anomalous developments;

- Institute performance measurement and verification activities to assess energy consumption, bill savings, and GHG reductions from project implementation;

- Design and build a performance tracking and information management database to help identify and assess the effectiveness of energy efficiency measures;

- Establish an accountability framework to hold agencies responsible for energy reduction in facility portfolios;

- Further develop centralized support and management of the Steering Committee's planning and coordination activities;

- Identify the full range of funding sources required to finance the Plan; and

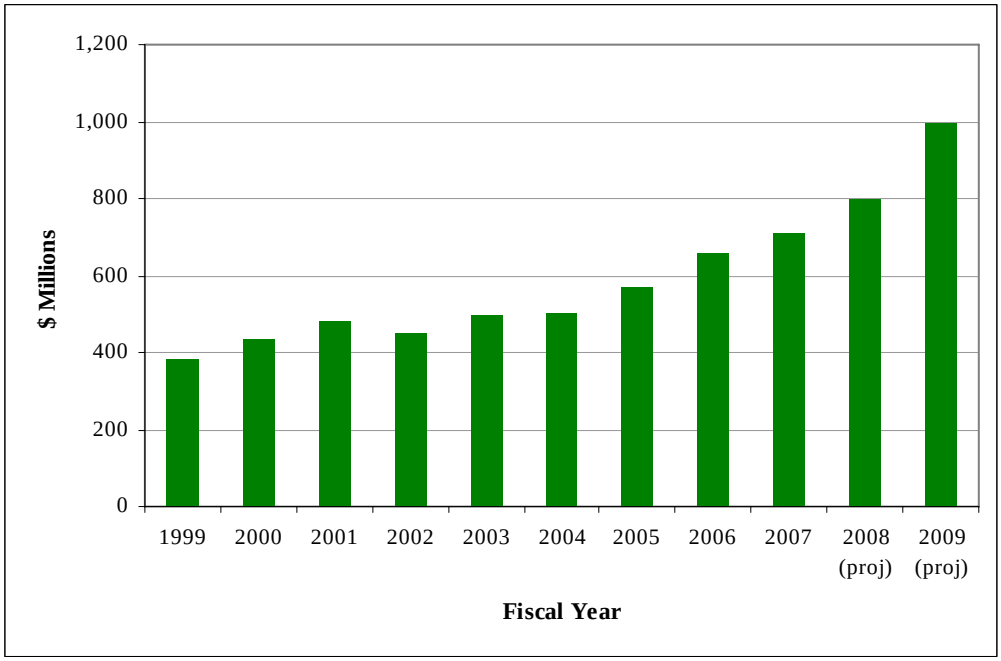
- Engage and seek input from the private sector, as well as share information through the PlaNYC Sustainability Advisory Board.

D. Financial Impact

As noted earlier, we estimate that achieving the targeted reduction of 1.68 million metric tons will require an investment of over $2.3 billion over the next nine years, approximately $900 million of which has already been committed by the City. While the City will pay for an additional portion of the overall investment through the agency appropriations process (e.g., routine maintenance and renovation projects which also often include GHG reduction savings), the City will still face a significant funding gap close to $1.4 billion. As such, the Steering Committee will explore additional funding from a variety of external sources, including state and federal grant programs, private foundations, utility programs, and energy performance contracts in order to identify the remainder of the funding requirement.

While the $2.3 billion commitment for the Plan is a significant investment, the energy bill savings generated will be large as well, particularly as energy costs continue to rise. Figure 3 below show the City's actual heat, light, power, and fuel spending over the last 10 years.

Figure 3: City's Annual Heat, Light, Power and Fuel Budget



Furthermore, as part of our research and analysis, we conducted detailed cost-benefit assessments for each of the project groups identified in Figure 2. Figure 4 below provides a summary of those assessments, including both the investments required and the bill savings expected from each group, with the simple payback (total project costs divided by annual bill savings) computed in the right hand column.[3] Overall, the average payback is estimated at 7.6 years, which equals a return on investment of roughly 13% per year on the project portfolio.

[3] Project costs do not include debt financing costs, implementation costs for SWMP, which have been budgeted separately, or emerging technology costs, which have not yet been identified.

Figure 4: Investment Costs and Annual Savings by Project Group[4]

Project Group	Investment Costs		Annual Bill Savings		Payback Period in Years
	$ Million	% of Total	$ Million	% of Total	
Equipment Replacement &Retrofit	$ 1,184	50.6%	$ 179	58.5%	6.6
Other Capital Measures	$ 219	9.4%	$ 20	6.6%	10.9
Operations & Maintenance	$ 435	18.6%	$ 54	17.7%	8.1
Street Lighting	$ 47	2.0%	$ 13	4.2%	3.6
Clean Distributed Generation	$ 126	5.4%	$ 11	3.6%	11.5
Vehicles	$ 218	9.3%	$ 12	3.9%	18.2
Wastewater Treatment Plants	$ 78	3.3%	$ 12	3.9%	6.5
New Construction	$ 32	1.4%	$ 5	1.6%	6.4
Total	**$ 2,339**	**100.0%**	**$ 306**	**100.0%**	**7.6**

Note: All amounts in FY‘08 dollars.

The Plan is expected to break even on an annual cash flow basis beginning in FY‘13 and on a cumulative basis beginning in FY‘15. In addition, we used a net present value approach to examine the cost-effectiveness of the overall Plan, the results of which indicate that over a 25-year planning horizon, the Plan will yield a positive net present value of $625 million. Based on our analyses, the range of activities required to meet the GHG reduction goal will generate significantly greater financial returns for the City than if we keep the status quo.

E. Conclusion

The City can successfully meet the 30% GHG reduction goal by 2017 through the implementation of an aggressive capital improvement program for its existing buildings, and significant enhancements to current O&M practices. Achieving our goal will require a concerted effort, including increased financial and organizational commitments over the next nine years, which we will continue to build on in FY‘09. Fulfilling this commitment will not only reduce our impact on global climate change, but will save the City money and yield other benefits, including improved air quality.

[4] Figure 4 does not include the Solid Waste Management Plan because costs for those measures are already assigned to other City initiatives. It also does not include costs for emerging technologies, which have not yet been specified.

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1 Introduction

1.1 Overview

The municipal government of the City of New York (City) produces approximately 3.8 million metric tons of greenhouse gas (GHG) emissions per year, and consumes about 6.5% of New York City's total energy usage. In Fiscal Year 2009 (FY'09) that usage is expected to amount to nearly $1 billion in energy costs for municipal buildings and operations. Given the magnitude of these environmental and financial impacts, on October 22, 2007, Mayor Michael R. Bloomberg signed Executive Order 109 and established the Energy Conservation Steering Committee (Steering Committee). The committee was charged with developing and implementing a comprehensive action plan (Plan) to reduce consumption and GHG emissions of City buildings and operations by 30% by 2017, thus advancing a key PlaNYC energy initiative. In addition, the Mayor announced an annual commitment equal to 10% of the City's energy budget to finance the Plan. Executive Order 109 also mandated the creation and execution of a short-term action plan for the remainder of FY'08, which the Steering Committee, chaired by the Deputy Mayor for Operations, issued on December 5, 2007. The enactment of Local Law 22 subsequently codified the GHG reduction goal laid out in Executive Order 109.

In addition to its Chair, the Steering Committee includes the Office of Operations/Long-term Planning and Sustainability (OLTPS), Office of Management and Budget (OMB), New York City Economic Development Corporation (EDC), Department of Design and Construction (DDC), and Department of Citywide Administrative Services (DCAS). Earlier this year, we enlisted a technical advisory team comprised of the energy consulting firms AECOM Technology Corp. and KEMA, Inc. (the Consultant), to conduct extensive research, interviews, and analysis on the various reduction opportunities available to the City and their relative cost-effectiveness.

In developing our Plan, the Steering Committee applied the following guiding principles:

- Focus on efficiency projects using currently-available, proven technologies and strategies to the maximum extent possible;
- Adjust for real resource constraints (e.g., operational, financial) limiting the scale and scope of projects to be considered;
- Incorporate best practices into operations and maintenance activities to ensure the appropriate use of existing equipment and new capital improvements;
- Analyze the financial impacts of implementation, including capital improvements, operating costs, and the extent to which energy bill savings these investments are expected to generate; and
- Coordinate and enhance existing energy conservation programs across the City.

1.2 Energy Conservation Efforts to Date

Over the years, the City has conducted a variety of programs, which are highlighted in the section that follows:

1.2.1 Capital Improvements Program

Since the inception of the New York Power Authority's Energy Cost Reduction Program (ENCORE) in 1995, the City has completed over 250 energy conservation capital improvement projects. Specifically, the City, through DCAS' Office of Energy Conservation (OEC), has conducted 279 projects in 325 buildings, at a total cost of $230 million. In the past 10 years, boiler replacements have accounted for one-third of total project costs, with lighting and chiller replacements accounting for an additional 25% each. The estimated value of annual energy savings associated with these projects is $22 million. Lighting projects accounted for almost half of the savings, with boiler replacements accounting for 26% and chillers accounting for 10%.

1.2.2 Energy Management Program

DCAS pays all utility bills for facilities owned and, in certain instances, leased by City agencies through OEC, which has tracked energy use and costs in City buildings and operations since the 1970s. OEC maintains energy consumption records at the account level, updating records on a monthly basis.[1] Each account is linked to individual facilities and separated for electricity, natural gas, and steam. Fuel oil used by buildings is not tracked by individual buildings; rather, records are kept at the agency level, as are vehicle fuel records.

OEC also provides energy management support to all agencies that occupy space for which the City pays energy bills. Specifically, OEC supports each agency's Energy Liaison Officer (ELO), whose principal functions include: (i) reviewing detailed billing reports prepared by OEC to identify estimated reads and large increases in consumption that might affect billing amounts, (ii) coordinating with capital planners and engineers to identify opportunities for energy efficiency projects in existing buildings, and (iii) identifying changes in agency energy use for annual budget planning. OEC provides support to the ELOs through the development and distribution of detailed billing reports and through training on various aspects of energy management.

1.2.3 Vehicle Fleet Program

A variety of City agencies, including the Departments of Citywide Administrative Services, Police, Fire, Correction, Sanitation, Transportation, Parks and Recreation, Environmental Protection, and Health and Mental Hygiene own and operate large vehicle fleets. Over the past 10 years, these agencies have taken a series of steps to reduce energy use and emissions in vehicles, including:

- Replacing large passenger cars and light trucks with smaller models;

[1] Other agencies, such as OMB and the Department of Education, also maintain facility databases.

- Purchasing low-emissions vehicles, including hybrid cars, electric carts, compressed natural gas, and low-sulfur diesel powered heavy trucks;
- Piloting use of bio-fuels such as bio-diesel and ethanol; and
- Implementing various maintenance routines designed to sustain high mileage, including the use of helium or nitrogen in truck tires to reduce leakage.

1.2.4 Standards for New Construction and Major Renovation Projects

In 2005, the Mayor signed Local Law 86 (LL 86), mandating that all City-funded capital projects with a construction cost of $2 million or more be designed and constructed to achieve the United States Green Building Council's Leadership in Energy and Environmental Design (LEED) Silver or higher rating, or for educational and healthcare institutions, a LEED Certified or higher rating. In addition, the law requires projects with construction costs of $12 million or more to reduce energy costs by 20% to 30% percent below the American Society of Heating, Refrigerating, and Air-Conditioning Engineers standard or the New York State Energy Conservation Code standard, whichever is more stringent. Other energy cost reduction requirements include those for projects not subject to LEED certification requirements that involve installation or replacement of boilers, lighting systems, or heating, ventilation and air conditioning controls. Additionally, domestic water use reduction is required for projects involving installation of plumbing systems. Residential, industrial, and high hazard occupancy classifications are exempt from this law, as are entities that are not City agencies unless 50% or more of the estimated project cost is funded by the City or if any project receives $10 million or more from the City, regardless of the percentage of the estimated project cost. Consistent with the provisions of LL 86, the New York City School Construction Authority and Department of Education (DOE) have developed the NYC Green Schools Guide, a rating system to guide the sustainable design, construction, and operation of new schools, as well as the modernization and renovation of existing schools.

Pursuant to Executive Order 97 of 2006, the Mayor's Office of Environmental Coordination administers LL 86, which includes promulgating rules, administering exemptions, working with City agencies to ensure compliance, determining if proposed alternative rating systems to LEED meet requirements, and compiling and publishing required annual reports.

1.2.5 Environmentally Preferable Purchasing

In 2005, the Mayor signed five Local Laws to create the Environmentally Preferable Purchasing (EPP) program, mandating the Mayor's Office of Contract Services to implement energy and water efficiency and environmental standards for a variety of products that the City purchases. These products include computers, office equipment, appliances, paints and solvents, cleaning products, and construction materials like windows, doors, and roofing. Certain "Non-Mayoral Agencies," such as the Health and Hospitals Corporation, are not covered by the EPP program.

1.2.6 Clean Distributed Generation Technologies

In January 2007, the Mayor signed Local Law 1, directing DCAS to assess all City facilities with peak electric demand greater than 500 kilowatts and determine whether combined heat and power or other natural gas-based distributed generation (e.g., microturbines) would be appropriate for those facilities. Over 300 facilities have since been assessed and ranked by economic attractiveness and technical feasibility for project development.

1.2.7 PlaNYC

In April 2007, the Mayor announced PlaNYC, an ambitious long-term sustainability plan for New York City's land, air, water, and energy supply, of which this Plan is a key initiative. PlaNYC contains 127 separate initiatives aimed at increasing access to open spaces; reclaiming brownfields; housing an additional one million New Yorkers affordably; ensuring reliability of water, energy and transportation infrastructure; reducing water pollution; improving efficiency of buildings and vehicles; and reducing greenhouse gas emissions by 30%. Additionally, as part of PlaNYC, OLTPS completed a comprehensive inventory of GHG emissions generated by the City as a whole and, more specifically, by City government buildings and operations.[2]

1.2.8 Short-Term Action Plan

Last December, the Steering Committee issued a short-term action plan to begin implementing a broad range of energy efficiency initiatives in FY'08, which included:

- Implementing 132 capital improvement projects, such as lighting, heating, ventilation and air conditioning (HVAC), water and sewer, and vehicle upgrades producing 33,882 tons in annual GHG reductions;
- Conducting an energy audit pilot program in 22 buildings to assess the current energy consumption of buildings;
- Initiating a LEED-EB and retrocommissioning assessment pilot program in 10 buildings to evaluate the benefit of each of those programs;
- Beginning an operations and maintenance study to examine existing practices at the City's largest energy-using agencies;
- Launching a metering and monitoring initiative to track energy consumption in buildings on an ongoing basis and analyze the need for energy conservation measures;
- Starting design for a database to connect energy consumption data recorded by systems throughout the City's building portfolio;
- Undertaking a small-scale renovations study; and

[2] Mayor's Office of Operations, Office of Long-Term Planning and Sustainability. April 2007. *Inventory of New York City Greenhouse Gas Emissions.* New York.

- Continuing DCAS's current vehicle fleet analysis on new technologies and best practices.

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2 Achieving GHG Emissions Reductions

Section 2 provides a detailed description of the baseline for GHG emissions in City buildings and operations and the tonnage reduction required to achieve the 30% reduction goal by 2017. Section 2 also provides a comprehensive review of the opportunities identified by the Steering Committee to meet the target, including cost-benefit analyses for implementing each.

2.1 The Emissions Baseline

2.1.1 Level and Pattern of Base Year Emissions

Local Law 22 of 2008 identified the GHG emissions generated in FY'06 as the baseline against which to measure the City's reduction. In April 2007, OLTPS conducted a comprehensive GHG inventory for FY'06, applying proven methodologies adopted by public and private sector organizations.[3] The emissions estimation models incorporated fuel use records, utility bills, technical studies of various City facilities, and operating records for vehicle fleets and industrial processes, such as wastewater treatment.

The inventory included the following, for which the City exercises direct control:

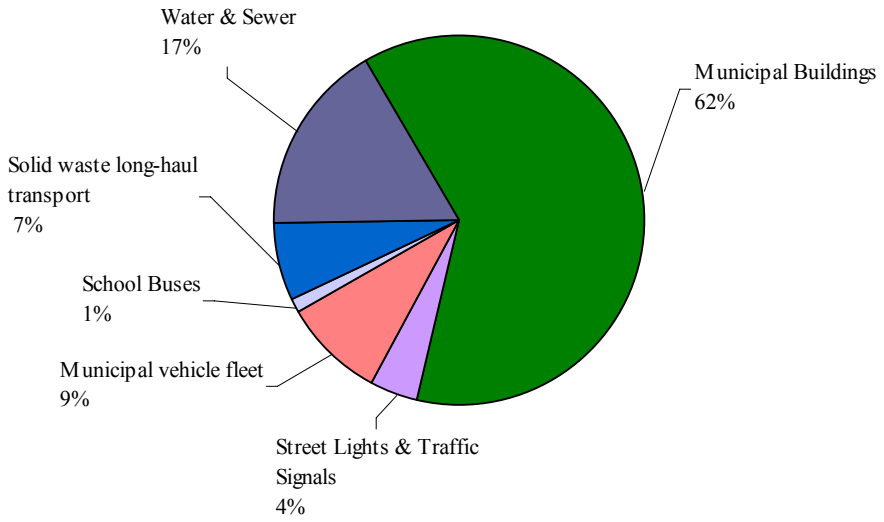
- ***Buildings.*** Electricity, natural gas, fuel oil, and steam consumption associated with City-owned and leased facilities.
- ***Vehicle Fleet.*** Gasoline and diesel fuel used by City-owned or leased vehicles, as well as fuel consumption by privately-owned school buses contracted by DOE and vehicles contracted by the Department of Sanitation for the export of solid waste.
- ***Street Lights.*** Electricity used for the operation of outdoor lighting on streets, roadways, and bridges, as well as traffic signals and lighted signs.
- ***Water and Sewer.*** Electricity, natural gas, and fuel consumption for all DEP facilities including water pollution control plants, wastewater pumping stations, water pumping stations, and methane leaks from wastewater treatment plants.
- ***Solid Waste.*** Net methane generated by the decomposition of landfill. In recent years, the closure of the Fresh Kills landfill and increased level of methane capture and combustion have essentially eliminated this source of GHG emissions.

The inventory also estimated emissions from sources for which the City exercises indirect control, such as fuel use from taxis and for-hire vehicles and gasoline use by employees who drive to work.[4] Overall, the inventory estimated the total FY'06 emissions from the five sources identified above at 3,840,470 metric tons of CO_2e. Figure 1 displays the distribution of those emissions among the principal sources.

[3] OLTPS used the Cities for Climate Protection methodology and the Clean Air and Climate Protection software developed by the National Association of Clean Air Agencies, the ICLEI – Local Governments for Sustainability, and Torrie Smith Associates, Inc. to develop the greenhouse gas inventory.

[4] These uses are not covered by Executive Order 109 and are not included in the base year emissions estimate.

Figure 1: CO_2e Emissions for City Government by Source (FY'06)
Total = 3.8 million metric tons



2.1.2 Trends in GHG Emissions

As part of its inventory, OLTPS developed emissions estimates for two background years, 1995 and 2001. OLTPS used these figures to assess trends and to support a business-as-usual forecast of emissions from the various sources through 2017. The forecast was used to establish the level of energy savings and emission reductions to be targeted through new investments and activities. Figure 2 displays the results of the historical analysis.

Figure 2: Historical CO_2e Emissions for City Government by Source

Source	CO_2e Emissions (Million Metric Tons/Year)		
	FY'95	FY'01	FY'06
Municipal buildings	2.168	2.497	2.444
Municipal vehicle fleet	0.281	0.341	0.366
DSNY long-haul trucks & trains	n/a	0.148	0.287
Solid waste disposal	0.086	-0.053	-0.055
Streetlights and traffic signals	0.194	0.184	0.144
Water and sewer	0.600	0.664	0.655
Total	**3.329**	**3.780**	**3.840**

This table highlights several key data points:

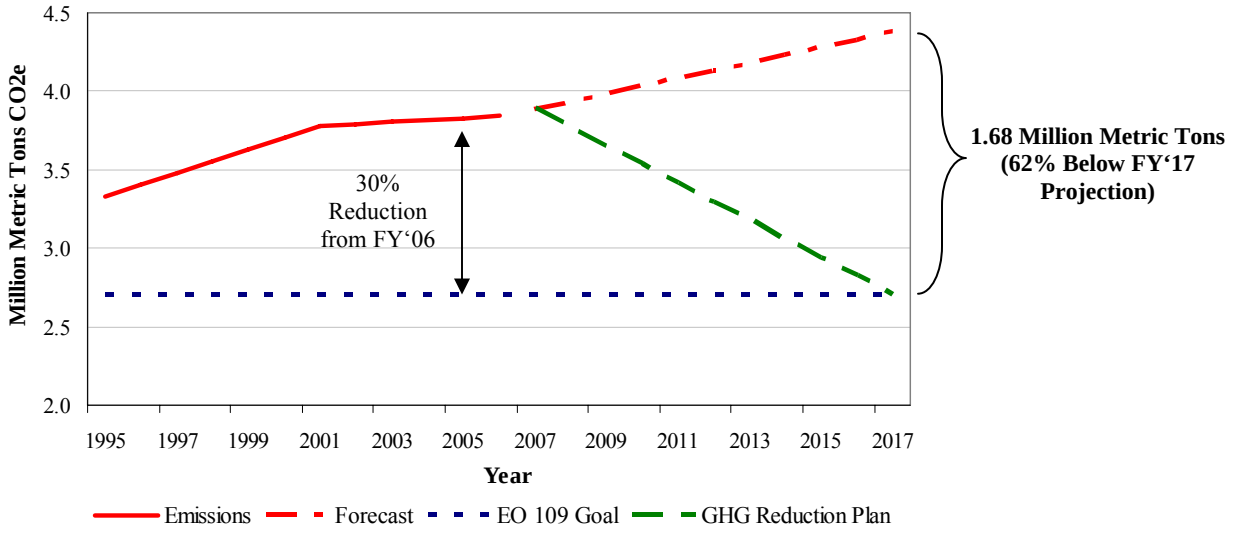
- Total emissions increased at a compound annual growth rate (CAGR) of 2.1% between 1995 and 2001 and then leveled to a pace of less than 0.4% between 2001 and 2006.
- The apparent decline in energy consumption in municipal buildings between 2001 and 2006 is likely due to the effects of weather on heating, cooling, and other weather-sensitive end-uses. For example, both the summer and winter of FY'06 experienced milder-than-normal temperature patterns. By contrast, emissions

from buildings in 2007 totaled over 2.82 million metric tons, consistent with the 2.1% annual growth rate in buildings between 1995 and 2001.

- Emissions associated with the operation of municipal vehicle fleets, including school buses, increased at a CAGR of nearly 3%.
- The City achieved a 25% reduction in energy use for street lighting and traffic signals through the replacement of all traffic signals with light-emitting diode lamps.

By substituting the FY'07 emissions of municipal buildings for the somewhat anomalous FY'06, the overall emissions from City operations increased at a compound annual rate of 1.9% between 2001 and 2007, a growth rate consistent with the rates of New York State's commercial and industrial customers.[5] Between 2008 and 2017, we estimate that the baseline growth rate will decelerate due to several factors, including rapid increases in fossil fuel prices and decreases in tax revenues due to the current downturn in economic activity.[6] Taking this into consideration, we used a compound annual growth rate of 1.2% to develop the business-as-usual forecast. Figure 3 below depicts the historical and expected growth of GHG emissions from City buildings and operations over the next nine years.

Figure 3: Projected CO_2e Emissions for City Government



Based on the information and assumptions concerning business-as-usual growth rates above, the Consultant forecasts that annual GHG emissions will reach 4.38 million metric tons by 2017. Thus, to meet the goals set forth in Local Law 22 and achieve a 30% reduction below the FY'06 baseline by 2017, the City must implement an aggressive and comprehensive strategy to reduce GHG emissions by 1.68 million metric tons annually, 62% below the FY'17 projection.[7]

[5] See retail sales data at http://www.eia.doe.gov.
[6] Office of Management and Budget, *Financial Plan Summary: Fiscal Years 2008 – 2012*. New York City, January 24, 2008.
[7] 4.38 million metric tons per year projected less 2.70 million metric tons per year.

2.2 Overview of Reduction Opportunities in GHG Emissions

2.2.1 Methodology

In the analysis of the City's opportunities for GHG reductions, we considered the following two questions:

- To what extent can GHG emissions be lowered using currently-available, proven technologies?
- How much will it cost to implement those measures?

In order to answer these questions, we estimated energy use reductions, energy cost savings, GHG reductions, and project investment costs as follows:

- ***Estimation of energy use by fuel and facility type for all facilities in City's GHG emissions inventory.*** The Consultant created a facility-level database with monthly consumption records and billing amounts for various fuels to produce its estimate.
- ***Estimation of energy use by facility type and end use.*** The Consultant used the facility-level database noted above in conjunction with the results of technical studies for energy use in New York State commercial and municipal facilities to disaggregate fuel use by end-uses, such as lighting, cooling, and heating for each building type.[8]
- ***Estimation of potential savings and costs associated with cost-effective measures.*** The Consultant collected data on the energy savings and investment costs of implementation for the full range of measures applicable to municipal facilities from recent technical and market studies conducted for the New York State Energy Research and Development Authority, City agencies, and other organizations.[9] The Consultant then used the data to estimate annual energy savings, electric demand reductions, and implementation costs for all measures that provided a combined payback of 10 years or less.
- ***Estimation of impact of resource constraints on the pace at which the City can implement projects.*** The Consultant conducted interviews with high-level staff at City agencies with substantial facility inventories and other key agencies to assess the City's ability to develop and manage a significantly higher number of energy efficiency projects and activities, using the results of its research to provide estimates on the number of different types of projects that the City could

[8] Optimal Energy, Inc. *Natural Gas Energy Efficiency Resource Development Potential in New York.* 2006. *Energy Efficiency and Renewable Energy Resource Development Potential in New York State.* Albany: New York State Energy Research and Development Authority.

[9] Optimal Energy, Inc. Electric Energy Efficiency Potential from Southeast New York Governmental Customers. 2008 White Plains: New York Power Authority.

potentially complete.[10] For example, the Consultant identified over 130 sites where the use of combined heat and power likely would prove cost-effective; however, given the complexity of these projects, as well as factors beyond the City's control, the Consultant estimated that the City should plan to implement only 30 such projects over the next nine years.

Reduction estimates for certain GHG sources were developed using variations of the approach described above. The consulting firm Booz Allen Hamilton (Fleet Consultant) is currently conducting a study of potential efficiencies in the municipal fleet using an approach similar to the one described above for facilities. Specifically, the Fleet Consultant projected energy consumption totals by vehicle type and function, assessed current vehicle purchase and maintenance practices, and estimated the implementation costs and potential savings of applying best practices to the City's operations. The Consultant incorporated the preliminary results of this study into its broader analysis. Additionally, the Consultant incorporated the savings and costs associated with the implementation of the SWMP from the technical reports used to support that initiative.

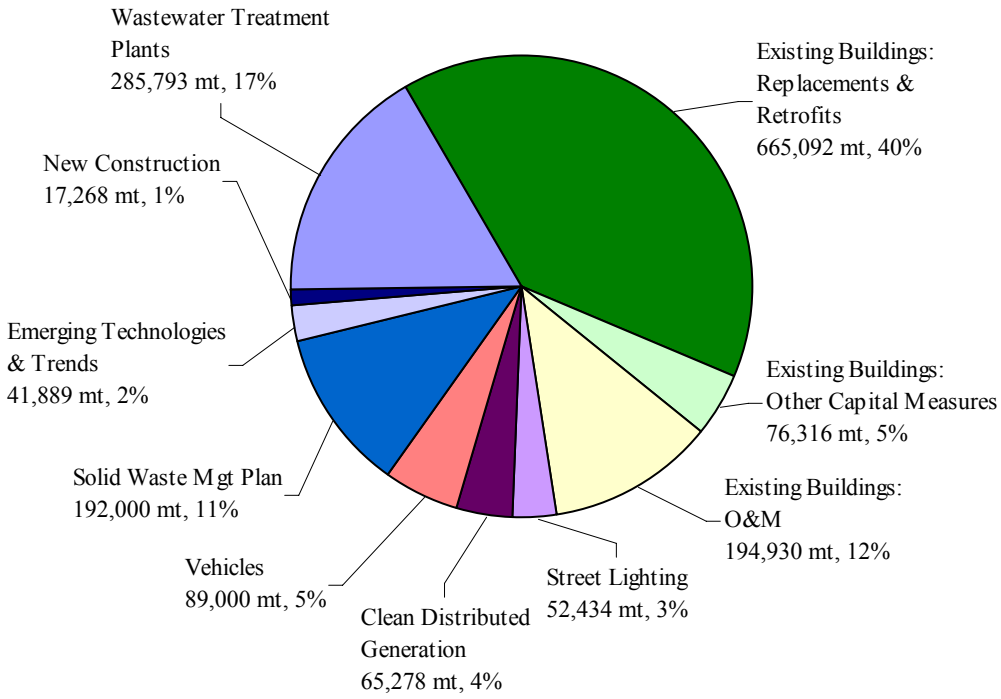
2.2.2 Opportunities for GHG Emissions Reductions

A. Reduction in Annual GHG Emissions

Figure 4 summarizes the results of the energy efficiency and GHG reduction potential analysis and provides a breakdown of the various efficiency measures by group. Figure 4 also includes the relative share of the reduction goal that can be achieved by each group to cut annual emissions by 1.68 million metric tons CO_2e by 2017.

[10] Agencies interviewed were: City University of New York, Department of Citywide Administrative Services, Department of Environmental Protection, Department of Correction, Department of Education/School Construction Authority, Department of Information Technology and Telecommunications, Department of Transportation, Department of Parks and Recreation, Department of Sanitation, Fire Department of New York, Health and Hospitals Corporation, Mayor's Office of Contract Services, Mayor's Office of Environmental Coordination, Police Department

Figure 4: Potential for Annual Greenhouse Gas Reductions by Project Group
Total = 1.68 million metric tons (mt) per year



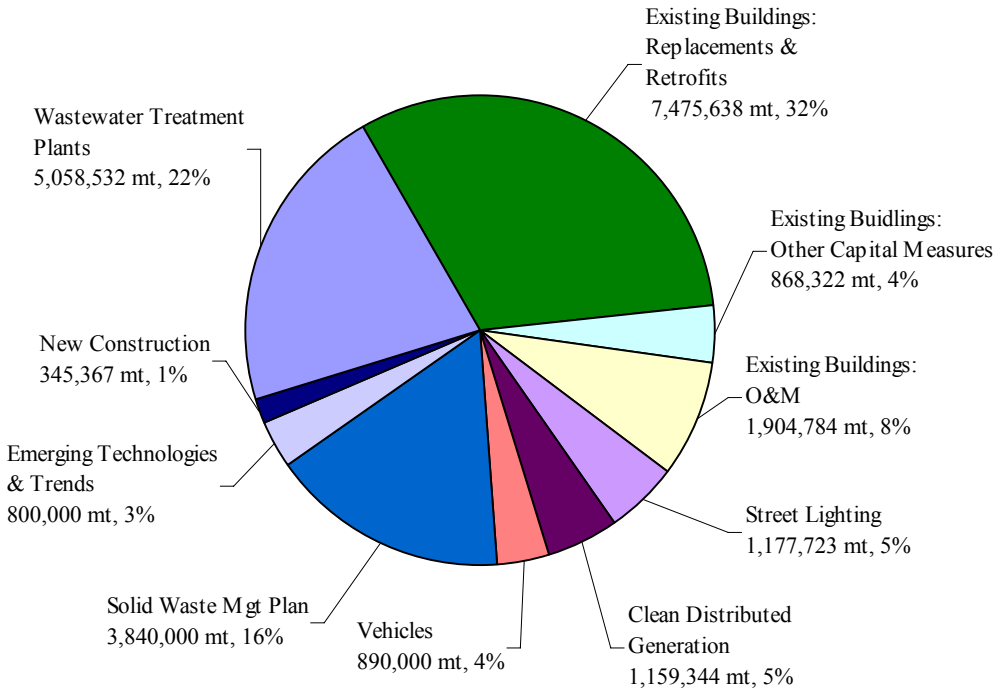
We estimate that cost-effective energy efficiency measures, including capital improvements and upgrades to current O&M procedures, can yield a total of 1.64 million metric tons per year in GHG reductions, or 98% of the reduction goal. We expect the City to achieve the remaining 2% through the improved efficiency of our electric power supply infrastructure and the application of emerging technologies. Improvements to existing buildings represent the largest share of potential GHG reductions identified with 57% of the total.

B. Reduction in Life Cycle GHG Emissions

In order to compare the GHG reduction impact of the project groups described above, the Consultant computed the life cycle GHG emissions for each project group. The life cycle analysis takes into account two key factors in comparing projects: (i) effective useful life (EUL) of a project, and (ii) decay in efficiency. With respect to useful lives, the life cycle analysis gives proportionately more weight to projects with longer useful lives because, simply put, projects that last longer achieve greater reductions. The useful life for typical projects in the groups identified range from 5 to 20 years. The second factor included in the life cycle analysis accounts for the decay of achieved reductions over time. Even after new installation, energy efficiency of certain types of equipment, such as air conditioning, refrigeration, and pumps, degrades over time, even if it is conscientiously maintained. This can reduce the overall impact of a project on GHG emissions over an extended period, which also must be accounted for when comparing the effectiveness of different project groups.

Figure 5 shows the estimated reduction of life cycle GHG emissions for each of the major project groups identified earlier.

Figure 5: Potential for Life Cycle Greenhouse Gas Reductions by Project Group
Total = 23.5 Million Metric Tons CO_2e



The Consultant's analysis resulted in total reduction in life cycle GHG emissions of 23.5 million metric tons. Improvements to existing buildings account for 44% on a life cycle basis, again representing the largest share of the reduction potential.

As mentioned earlier, other things being equal, projects with longer effective useful lives will produce greater life cycle reductions. The following illustrates this point by comparing the data from Figure 4 with data from Figure 5:

- The share of total life cycle reductions from efficiencies in wastewater treatment plants is 22% versus 17% for annual reductions. These improvements are projected to have a 20-year useful life, compared to measure lives of 12 to 15 years for electrical and mechanical system components in buildings.
- The share of total life cycle GHG reductions from the SWMP is 16% versus 11% for annual reductions. Since the substitution of rail and barge for truck-based transport is permanent, the savings will be realized without any of the reductions due to the wear and tear that affect the performance of several other project groups (e.g., building retrofits) over time.

2.2.3 Overview of Project Investment Costs and Annual Energy Cost Savings

A. Investment Costs and Annual Energy Cost Savings

Figure 6 displays the Consultant's estimates of the total capital and O&M investments required to implement the GHG reduction projects included in each project group identified.[11] The table also shows the estimated annual energy cost savings and payback period for each project group.

Figure 6: Investment Costs and Annual Savings by Project Group

Project Group	Investment Costs		Annual Bill Savings		Payback Period in Years
	$ Million	% of Total	$ Million	% of Total	
Equipment Replacement &Retrofit	$ 1,184	50.6%	$ 179	58.5%	6.6
Other Capital Measures	$ 219	9.4%	$ 20	6.6%	10.9
Building Operations & Maintenance	$ 435	18.6%	$ 54	17.7%	8.1
Street Lighting	$ 47	2.0%	$ 13	4.2%	3.6
Clean Distributed Generation	$ 126	5.4%	$ 11	3.6%	11.5
Vehicles	$ 218	9.3%	$ 12	3.9%	18.2
Wastewater Treatment Plants	$ 78	3.3%	$ 12	3.9%	6.5
New Construction	$ 32	1.4%	$ 5	1.6%	6.4
Total	**$ 2,339**	**100.0%**	**$ 306**	**100.0%**	**7.6**

Note: All amounts in FY'08 dollars.

The investment for all GHG reduction projects identified in the Plan totals over $2.3 billion in FY'08 dollars. Not surprisingly, upgrades to existing buildings account for the majority of investment costs and potential energy cost savings identified. Equipment replacement and retrofit projects account for 50.6% of the total investment and 58.5% of total energy cost savings, while operations and maintenance improvements are the next largest category, accounting for 18.6% of the total investment and 17.7% of total energy cost savings.

The payback periods for the various project groups analyzed range from 3.6 to 18.2 years, with a portfolio average of 7.6 years.[12] This amounts to an average yearly return on investment of over 13%. Based on this analysis, almost all of these projects have a negative cost when energy cost savings are considered. Therefore, the City can expect to realize significant savings from its investments toward this Plan**.** In addition, the Consultant's analysis did not include targeted peak load demand reductions, which if implemented, could further increase energy cost savings.

[11] Figure 6 does not include the costs or savings associated with implementation of the Solid Waste Management Plan or with the school boiler replacement program. The costs for those measures are already assigned to other City initiatives.

[12] Generally, the City pays lower energy costs through its contract with NYPA than energy costs paid by private customers to other utilities. The payback for a comparable portfolio of projects in the private sector would likely be shorter.

B. *Abatement Costs*

An alternative method to compare the cost-effectiveness of these projects is to compute the "abatement cost," an indicator which not only reflects the differences between projects in required capital investment and operating costs, but also differences in potential energy savings, fuel mix, and effective useful lives. A recent report by the consulting firm McKinsey & Co. for The Conference Board contains such an indicator, which the authors call the "Cost of an Abatement Option."[13] The "abatement cost" is calculated as the net present value of the stream of capital and operating costs associated with implementing a project offset by energy cost savings, and divided by the number of tons of emissions reduced over the project's effective useful life.

Measures that are highly cost-effective have a negative "abatement cost," since they provide the investor with acceptable levels of energy services (e.g., sufficient lighting or cooling) at a life cycle cost below that of the "standard efficiency" technology option. Figure 7 summarizes the results of the Consultant's analysis on abatement costs for each group of projects.

Figure 7: Abatement Costs by Project Group

Project Group	Project Subcategory	Cost/ton
Wastewater Treatment Plants	Methane Capture & Generation	$ (158)
Other Capital Measures	Street Lighting	$ (149)
Equipment Replacement & Retrofit	Equipment Replacement	$ (114)
Wastewater Treatment Plants	Retrofits	$ (92)
Equipment Replacement & Retrofit	Audit/Retrofit	$ (63)
Other Capital Measures	ITT Improvements	$ (58)
Facilities Operations and Maintenance	Improved O&M	$ (11)
Facilities Operations and Maintenance	Retrocommissioning[14]	$ (10)
Clean Distributed Generation	Combined Heat & Power	$ (9)
Vehicles	Municipal Fleet Upgrades	$ 52
Other Capital Measures	Advanced BMS	$ 52
Clean Distributed Generation	Solar Photovoltaic	$ 157
Total		**$ (52)**

This analysis further validates the economic potential of implementing the portfolio of GHG reduction projects identified. The average abatement cost of all measures in the portfolio is negative $52 per ton, indicating that the overall portfolio is highly cost-effective and generates significant present value savings to the City.

[13] McKinsey & Company. 2007. *Reducing U. S. Greenhouse Gas Emissions: How Much at What Cost?* The Conference Board. December 2007.

[14] Implementation of some retrocommissioning measures is included in the equipment replacement and retrofit category.

2.2.4 Other Benefits of GHG Reductions

While the goal of the Plan is meeting the City's GHG reduction target, the recommended projects also provide additional benefits. Most of the City's GHG emissions, with the exception of those associated with wastewater treatment and landfills, are a result of burning fossil fuels, as is most air pollution. In fact, the largest sources of fine particulate matter (PM 2.5) in the City are burning fossil fuels used to heat and power buildings. As a result, measures that improve energy efficiency and, thus, reduce electricity and fuel consumption also contribute to cleaner air, both indoors and outdoors.

These projects also help improve the reliability of an area's electricity infrastructure and reduce energy costs, specifically those measures that reduce peak electricity demand. During peak demand periods (e.g., hot, sunny days), the electricity grid is more vulnerable due to added pressure, and older, less efficient power plants often are used to meet demand, thereby compromising air quality in addition to driving up electricity costs. Measures that reduce the City's demand save money, both in terms of reduced consumption and reduced demand charges. According to the Consultant's analysis, these potential benefits include:

- ***Relieving pressure on the grid.*** Assuming the full implementation of all the recommended electricity projects, the Consultant estimates a reduction on peak load demand of 227 to 256 megawatts by 2017, or by comparison, approximately one-half of the capacity of a typical power plant used to meet peak demands in the New York area. If peak loads are specifically targeted in addition to these conservation measures, demand reductions could be even greater than those estimated here.
- ***Reducing demand and delivery charges paid by the City.*** Estimates range from $18 to $22 million a year.

2.3 Breakdown of GHG Reduction Project Groups

Figure 8 lists the project subcategories analyzed, along with key summary indicators of costs, energy cost savings, and GHG reductions estimated for the respective categories. The sections that follow provide a description of each subcategory, its associated investment cost, energy savings, and energy cost savings.

Figure 8: Breakdown of Investment Cost and Savings by Project Subcategory

Project Subcategory	Investment Cost		Annual Energy Cost Savings		Annual CO_2e Reductions	
	$ mil	% of total	$ mil	% of total	tons ('000s)	% of total
Existing Buildings: Equipment Replacements and Retrofits						
Replacements	182	7.8%	37	12.1%	137	8.2%
Retrofits	1,002	42.8%	142	46.4%	528	31.4%
Existing Buildings: Other Capital Measures						
Replacement of Oil-Burning Boilers	*	*	2	0.7%	7	0.5%
Advanced BMS	211	9.0%	17	5.6%	66	3.9%
Data Centers	8	0.4%	1	0.3%	3	0.2%
Existing Buildings: Operations and Maintenance						
Improved Practices	423	18.1%	51	16.7%	185	11.0%
Retrocommissioning	12	0.5%	3	1.0%	10	0.6%
Street Lighting						
Street Lighting	47	2.0%	13	4.2%	52	3.1%
Clean Distributed Generation						
Combined Heat and Power	106	4.5%	10	3.3%	62	3.7%
Solar Photovoltaic	20	0.9%	1	0.3%	3	0.2%
Vehicles						
Fleet Upgrades and O&M	218	9.3%	12	3.9%	89	5.3%
Solid Waste Management Plan						
Solid Waste Management Plan	*	*	*	*	192	11.4%
Wastewater Treatment Plants						
Methane Capture & Generation	35	1.5%	8	2.6%	266	15.8%
Retrofits	43	1.8%	4	1.3%	20	1.2%
New Construction						
New Construction	32	1.4%	5	1.6%	17	1.0%
Emerging Technologies and Trends						
Emerging Technologies & Trends	**	**	**	**	42	2.5%
Total	**2,339**	**100.0%**	**306**	**100.0%**	**1,680**	**100.0%**

* Costs and savings attributed to other City initiatives.
** Emerging technologies and trends not specified for this analysis.

2.3.1 Equipment Retrofit and Replacement Projects

Equipment replacements and retrofits in existing buildings account for the largest potential GHG reductions across all of the project groups identified, representing 39.6% of the total reduction or 665,092 metric tons of CO_2e per year. Retrofits include both targeted system upgrades (e.g., lighting) as well as more comprehensive approaches to building upgrades (e.g., full-building audits and retrocommissioning). These measures

account for 50.6% of the total investment in GHG reduction projects and account for 58.5% of the total potential energy cost savings.

A. Summary of Energy and Cost Savings

Equipment Replacement			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Electricity	(GWh)	136	$16.3
Natural Gas	(Therms '000)	5,238	$7.9
Oil	(Gallons '000)	3,158	$10.3
Steam	(MLB)	118,959	$2.6
		TOTAL	**$37.1**
Investment Cost		**$182 million**	
Annual CO_2e Reductions		**137,220 metric tons**	

Equipment Retrofit			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Electricity	(GWh)	616	$73.8
Natural Gas	(Therms '000)	16,571	$24.9
Oil	(Gallons '000)	10,138	$33.2
Steam	(MLB)	456,890	$10.1
		TOTAL	**$141.9**
Investment Cost		**$1,002 million**	
Annual CO_2e Reductions		**527,872 metric tons**	

B. Project Description

This project group consists primarily of replacements of older, inefficient equipment in buildings with newer, efficient models that meet or exceed current product standards and codes for energy efficiency. Examples include upgrades to lighting, HVAC, and refrigeration systems. For retrofits, the Consultant included both targeted system upgrades and a comprehensive building approach that combines building audits with retrocommissioning and identified retrofits. The Consultant analyzed the potential savings of roughly 80 replacement and retrofit measures aimed at reducing electricity in existing buildings and 40 replacement and retrofit measures aimed at reducing gas, oil, and steam use. Figure 9 shows a selection of the specific measures analyzed.

Figure 9: Sample of Measures Analyzed

Electricity	Natural Gas, Fuel Oil, Steam
Lighting	**Heating**
"Super T-8" fluorescent fixtures, ballasts, lamps T-5 fixtures T-5 substitute for high intensity discharge (HID) fixtures in high bay applications Pulse-start HID fixtures Occupancy controls Daylight dimming controls LED lighting arrays Efficient lighting designs and layouts Compact fluorescent bulbs	High efficiency packaged unit furnace High efficiency boiler – condensing Programmable thermostat Demand controlled ventilation Outdoor reset boiler control Improved wall insulation High performance glazing Air sealing Pipe insulation Heat recovery devices Oxygen trim
Cooling	**Water Heating**
High efficiency packaged air conditioners High efficiency heat pump High efficiency chiller Optimized cool air distribution systems Dual enthalpy controls Advanced cooling controls	Faucet aerators Gray water heat exchanger Indirect-fired heating boiler Instantaneous, high modulating water heater Pipe and tank insulation
Office Equipment	**Cooking (natural gas only)**
High efficiency CPU and computer display Low mass copier High efficiency printers & fax High efficiency internal power supply	Exhaust hood make-up air Direct-fired convection range/oven High efficiency fryers, cookers, griddles Refrigeration heat recovery
Refrigeration	
High efficiency remote refrigeration Refrigeration economizers Walk-in refrigeration retrofit package	N/A
Building Shell	
High performance glazing (cooling & heating)	N/A
Motor Systems	
Premium efficiency motors Variable speed drives	N/A

Electricity	Natural Gas, Fuel Oil, Steam
Water Heating	
Point of use water heater	N/A

C. Replacement versus Retrofit Measures

Replacement opportunities are upgrades of failing equipment beyond its effective useful life. Retrofit opportunities are upgrades to functional, but often old and inefficient, equipment specifically to achieve energy savings. For purposes of this analysis, the Consultant assumed that the majority of measures in the project group (80% by savings) would be retrofits.

2.3.2 Other Capital Measures

These measures account for 4.6% of the total reduction or 76,316 metric tons of CO_2e per year. This group makes up 9.4 % of the total investment cost and 6.6% of total potential annual energy cost savings.

A. Replacement of Oil-Burning Boilers

A.1. Summary of Energy and Cost Savings

Replacement of Oil Burning Boilers			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Natural Gas	(Therms '000)	(2,377)[15]	($3.6)
Oil	(Gallons '000)	1,800	$5.9
		TOTAL	**$2.3**
Investment Cost		**$N/A**[16]	
Annual CO_2e Reductions		**7,501 metric tons**	

A.2. Project Description

This group includes projects to replace outdated school boilers that currently burn #4 or #6 heating oil with burners and/or boilers that use #2 oil, natural gas, or both. Replacement of these boilers often also requires the replacement of significant pieces of ancillary equipment and controls, which generally results in even greater efficiencies.

[15] Gas savings are negative due to substitution of gas for oil

[16] This measure will be funded separately through PlaNYC initiative 10 under Air Quality: Reducing Emissions from School Boilers in High Asthma Areas.

B. Advanced Building Management Systems (BMS)

B.1. Summary of Energy and Cost Savings

Advanced BMS			
		Annual Savings	
		Energy Units	**Energy Cost ($Mil)**
Electricity	(GWh)	108	$13.0
Natural Gas	(Therms '000)	2,669	$4.0
		TOTAL	**$17.0**
Investment Cost		**$211 million**	
Annual CO_2e Reductions		**66,054 metric tons**	

B.2. Project Description

This group consists of projects that install new, automated BMS in buildings to monitor and control energy use. These electronic systems control lighting, HVAC, and other mechanical systems to match energy use to a facility's occupancy schedule and other conditions. The systems also monitor energy use at the whole-building or end-use component level. Building operators can use the resulting information to target O&M initiatives to further reduce energy consumption. Most large, commercial buildings built or renovated in the past 25 years have centralized BMS. Recent technical advances in electronic control technology and wireless communications, as well as the standardization of communication protocols, have produced improvements in the energy monitoring and control capabilities of BMS, including the coordinated management of multiple facilities.

C. Energy Efficiency in Data Centers

C.1. Summary of Energy and Cost Savings

Energy Efficiency in Data Centers			
		Annual Savings	
		Energy Units	**Energy Cost ($Mil)**
Electricity	(GWh)	6	$0.7
		TOTAL	**$0.7**
Investment Cost		**$8.4 million**	
Annual CO_2e Reductions		**2,761 metric tons**	

C.2. Project Description

This group includes computer servers and auxiliary equipment. According to several studies, these account for slightly more than half of the electric demand in a typical data center with required cooling accounting for an additional 25%. The remainder is

generally lighting and other support systems.[17] The Consultant used studies on computer server technology and best practices to estimate the GHG reduction potential across the City's data centers. The Department of Information Technology and Telecommunications is currently conducting more detailed analyses related to this area.

2.3.3 Existing Buildings: Operations and Maintenance

Enhancements to O&M practices in existing buildings accounts for 11.6% of the total GHG reduction or 194,930 metric tons of CO_2e per year, contributing 18.6% of the total investment cost and 17.7% of projected annual energy cost savings.

A. Improved Operations and Maintenance

A.1. Summary of Energy and Cost Savings

Improved O&M			
		Annual Savings	
		Energy Units	**Energy Cost ($Mil)**
Electricity	(GWh)	122.5	$14.7
Natural Gas	(Therms '000)	8,034.0	$12.1
Oil	(Gallons '000)	5,664.0	$18.5
Steam	(MLB)	280,123	$6.2
		TOTAL	**$51.4**
Investment Cost		**$423 million**	
Annual CO_2e Reductions		**185,318 metric tons**	

A.2. Project Description

Improving O&M procedures consists primarily of developing and implementing preventive practices in major energy-consuming buildings, including identification and correction of conditions that might lead to energy waste, such as leaking pipes, clogged steam traps, and inefficient heating, cooling, hot water, air distribution, pumps, and fan systems. Figure 10 displays a selection of procedures required to keep these systems operating in an energy-efficient manner. In order to achieve energy savings, these procedures must be implemented on a preventive or predictive basis. Preventive maintenance is conducted on a regular schedule, based upon manufacturers' recommendations and local operating experience. Predictive maintenance activities are conducted as required, based on the results of regular monitoring of equipment operation.

[17] Jennifer D. Mitchell-Jackson. 2001 *Energy Needs in an Internet Economy: A Closer Look at Data Centers.* Masters Thesis, University of California, Berkeley. May 2001.
Lawrence Berkeley National Laboratories. 2005. *Design Recommendations for High Performance Data Centers.* Berkeley, CA: 2005.
American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). 2006. *Design Considerations for Data Center and Communication Equipment Centers.*

Figure 10: Select Maintenance Procedures to Reduce Energy Consumption

System / Component / Issue	Maintenance Task
Space heating equipment and controls	
Steam trap maintenance	Observe monthly – repair immediately
Boiler or furnace operating controls	Calibrate and adjust pressure and/or temperature limits and set points Verify sequencing of boilers
Boiler and burner performance	Check/correct fuel mix, excess air, nozzle replacement, fuel filter replacement, draft fan or damper adjustments
Boiler heat transfer	Annual waterside and fireside cleaning
Steam boiler blowdown losses	Minimize blowdown rate for consumption through optimizing the water quality
Steam boiler water treatment	Test/treat water
Steam and water distribution and controls	
Steam to hot water heat exchanger heat losses	Confirm PRV, control valve, traps and temperature controls on converter are operating correctly
Leaks	Check all joints and valves for leaks – repair as soon as possible
Domestic Hot Water	
Pump Operations	Confirm circulating pump controls operate
Temperature settings	Set to minimum acceptable temperature
Domestic hot water heater sequencing	Change from boiler to stand-alone as soon as heating is no longer needed
Water-cooled chillers (electric or steam)	
Chiller efficiency	Clean condenser tubes
	Clean evaporator tubes
	Verify/correct operating schedule
	Verify/correct chilled water temperature and resets
	Verify/correct condenser temperature and resets
	Verify correct sequencing of chillers/cooling towers
Air-Cooled AC units	
General	Clean condenser coils
	Change filters as needed
	Confirm refrigerant charge
	Clean evaporator coils
	Confirm condenser fan operation
	Confirm compressor sequencing
	Check for correct schedule and temperature control
Pumps	
General	Lubricate
	Check seals for leakage
	Check for correct sequencing
	Check for correct speed/volume control

System / Component / Issue	Maintenance Task
Air Distribution Systems and terminal units	
General	Repair leaks in air handling units and ducts
	Confirm proper outside air damper control in economizer, minimum-air, and unoccupied operating mode
	Confirm proper operation of variable air volumes and controls, confirm proper operation of variable frequency drivers
Filters	Inspect monthly, replace filters as needed
Fans	Check belts and pulleys, tighten/replace as needed

B. Retrocommissioning

B.1 Summary of Energy and Cost Savings

Retrocommissioning			
		Annual Savings	
		Energy Units	**Energy Cost ($Mil)**
Electricity	(GWh)	16.4	$2.0
Natural Gas	(Therms '000)	320.0	$0.4
Oil	(Gallons '000)	6.7	N/A
Steam	(MLB)	46.0	N/A
		TOTAL	**$2.5**
Investment Cost		**$12 million**	
Annual CO_2e Reductions		**9,612 metric tons**	

B. 2. Project Description

Retrocommissioning is a process that systematically identifies the most wasteful inefficiencies that technicians can cost-effectively correct and restore the building's original level of energy-efficient operation. Retrocommissioning is usually carried out in relatively large commercial buildings (over 80,000 square feet) that are equipped with functioning BMS. Retrocommissioning most often generates energy savings by identifying and correcting instances in which the control functions of the BMS and connected equipment have deteriorated over time or in which control sequences no longer correspond to facility use and occupancy.

Retrocommissioning typically involves several stages, the first of which consists of monitoring and analyzing building energy use as well as testing of key components of the HVAC and control systems. This analysis enables engineers to identify efficiency measures to address anomalies in energy use, equipment schedules, and control sequences that may lead to energy waste. Typically, these measures fall into two categories: O&M and capital upgrades. Best practices in retrocommissioning call for

continued monitoring of energy use and periodic functional testing of key system components in order to maintain optimal operating conditions.

For the purposes of the Plan, the costs and potential energy savings of longer-term capital projects which are the result of retrocommissioning analyses are accounted for under the replacement and retrofit category.

2.3.4 Street Lighting

Street lighting upgrades account for 3.1% of the total GHG reduction or 52,434 metric tons of CO_2e per year, 2.0% of total investment costs, and 4.2% of the estimated energy cost savings.

A. Summary of Energy and Cost Savings

Street Lighting			
		Annual Savings	
		Energy Units	**Energy Cost ($Mil)**
Electricity	(GWh)	111	$13.3
		TOTAL	**$13.3**
Investment Cost		**$46.8 million**	
Annual CO_2e Reductions		**52,434 metric tons**	

B. Project Description

This group includes Citywide replacement of 250 watt and 150 watt street lighting with fixtures that maintain equal lighting levels using one-third less wattage. DOT is currently replacing street lighting throughout Queens and Brooklyn, and expects to complete upgrades in all five boroughs over the next three years.

2.3.5 Clean Distributed Generation

Clean distributed generation technologies are a way of expanding on-site electricity generation at City facilities. Leading examples include combined heat and power (CHP) and solar photovoltaic (PV) systems, which in this analysis account for 3.9% of the total reduction or 65,278 metric tons of CO_2e per year, as well as 5.4% of total investment cost and 3.6% of potential energy cost savings.

A. *Combined Heat and Power*

A.1. *Summary of Energy and Cost Savings*

Combined Heat & Power			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Electricity	(GWh)	448.0	$50.4
Natural Gas	(Therms '000)	(26,577)[18]	($39.9)
		TOTAL	**$10.5**
Capital Investment Cost		**$106.3 million**	
Operating Expense Investment Cost		**$3.4 million**	
Annual CO_2e Reductions		**62,433 metric tons**	

A.2. *Project Description*

This group consists of a small number of large projects to install combined heat and power (also known as cogeneration) systems in existing buildings. Cogeneration systems burn gas to create electricity that is used on-site. Waste heat, a byproduct from this process, is used to drive heating and cooling equipment, which results in very high overall efficiencies in energy use. The City operates many large facilities with long daily operating schedules, such as university campuses and correctional facilities, which are excellent opportunities for cogeneration systems.[19] While these systems can be highly cost-effective, implementation and continued economic viability are subject to a number of regulatory and price risks.

The potential effects of these risks need to be considered in the development of cogeneration systems. To reflect these risks in addition to the highly technical installation and long lead time required, the Consultant accounted for only 30 cogeneration projects over the next nine years in its analysis.

[18] Gas savings are negative due to use as a fuel to generate electricity.
[19] Cogeneration is the simultaneous generation of heat, and electrical energy through reciprocating engines or turbines located on-site.

B. Solar Photovoltaics

B.1. Summary of Energy and Cost Savings

Solar PV			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Electricity	(GWh)	6.0	$0.7
		TOTAL	**$0.7**
Investment Cost		**$20 million**	
Annual CO_2e Reductions		**2,845 metric tons**	

B.2. Project Description

Solar photovoltaics (PV) consist of panels of silicon cells that convert sunlight into electricity, as well as electronics that aggregate the direct current output of the cells and convert it into alternating current power. With current technology, roughly 80 square feet of installed cells are required to produce one kW of power. Current prices are roughly $120 per square foot installed. [20] Due to recent market trends, the Consultant anticipates that these prices will decline over the near-term.

The City recently released a RFP to private solar developers to purchase, install, own and maintain solar panels on City-owned buildings that would generate a total of 2 megawatts of solar electricity capacity in exchange for a 20-year power purchase agreement. Successful implementation of the RFP will further contribute to the GHG reductions identified in this analysis.

2.3.6 Vehicles

GHG reductions from improved vehicle efficiency and fleet management are expected to amount to an estimated 89,000 metric tons of CO_2e per year, or 5.3% of the total. The cost of the vehicle efficiency projects account for 9.3% of total investment costs and 3.9% of total estimated energy cost savings.

[20] Long Term Strategic Plan – Municipal Land Use Study: Final Report Appendix D – Compendium of Best Practices for Greater Municipal Land Use Efficiency (January 5, 2007).

A. *Summary of Energy and Cost Savings*

Vehicles			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Electricity	(GWh)	(8.8)	N/A
Natural Gas	(Therms '000)	7,662.0	N/A
		TOTAL	**$12.0**
Investment Cost		**$218 million**	
Annual CO_2e Reductions		**89,000 metric tons**	

B. *Project Description*

The Fleet Consultant is currently completing a study of potential cost and emission reductions in the municipal fleet. The preliminary version of the report identifies the following measures to reduce energy consumption and emissions from the municipal fleet:

- ***Better fuel tracking and accounting.*** If a comprehensive citywide fuel monitoring system is put in place and appropriate incentives are established for fuel conservation, reductions of roughly 5% can be expected.
- ***Vehicle efficiency improvements.*** The City can reduce fuel use and carbon emissions by increasing the fuel efficiency of the light, medium, and heavy-duty vehicles in its municipal fleet. Fuel efficiency improvements include replacing larger vehicles with smaller models (rightsizing), purchasing advanced-technology vehicles such as hybrids and plug-in hybrids, and piloting new powertrains such as hydraulic hybrids and electric vehicles.
- ***Biofuels.*** Biofuels (including cellulosic ethanol and biodiesel) can offer lower lifecycle carbon emissions than fossil-based fuels. Biofuels can be used in conventional vehicles or can be combined with advanced powertrains to yield even larger GHG reductions.[21]
- ***Vehicle tracking technologies.*** It is assumed that a reduction of about 3% to 5% in vehicle miles traveled could be realized by implementing vehicle tracking technologies in the light duty fleet.
- ***Anti-Idling Technologies.*** There are a variety of technologies and policies that can be applied to vehicles to reduce idling, ranging from driver warnings to automatic vehicle shut downs.
- ***Fleet and/or mileage reductions.*** This measure assumes no fleet growth – that is, agencies must serve a larger number of clients without adding vehicles. In

[21] Recent research has raised questions about the overall impacts of biofuel on GHG emissions and on food supplies. Currently, both the U.S. Environmental Protection Agency and the California Air Resources Board are developing standards for biofuels that will not have negative effects and it is anticipated that the City will adopt one of these standards.

actuality, this measure will require fleets to implement new strategies and make operational changes that more effectively utilize their current fleet assets.

2.3.7 Solid Waste Management Plan (SWMP)

The full implementation of the SWMP is expected to achieve GHG reductions of 192,000 metric tons of CO_2e per year, or 11.4% of the total. Investment costs and energy cost savings are not included in our analysis because this initiative is accounted and tracked by other dedicated sources within the City's budget.

A. Project Description

The SWMP fundamentally restructures the handling of solid waste in the City. Passed in 2006, the SWMP calls for the City to build a rail- and barge-based network to replace long-haul trucking for waste disposal services. As a result, Sanitation trucks will travel approximately 2.7 million fewer miles per year, and travel by tractor-trailer trucks will be reduced by 3 million miles per year.

2.3.8 Wastewater Treatment Plants (WWTPs)

Improvements to DEP's WWTPs represent the second largest opportunity for GHG reductions, accounting for 17% of the total or 285,793 metric tons of CO_2e per year. WWTP projects account for 3.3% of total investment costs and 3.9% percent of potential annual energy cost savings. WWTPs decontaminate sewage and storm water runoff through a series of physical, chemical, and biological processes, and release the water back into the environment once it has been cleaned. These processes generate significant amounts of methane gas, one of the strongest GHG emissions sources.

A. Methane Containment and Cogeneration Projects

A.1. Summary of Energy and Cost Savings

Methane Containment and Cogeneration			
		Annual Savings	
		Energy Units	**Energy Cost ($Mil)**
Electricity	(GWh)	246.0[22]	$8.0
		TOTAL	**$8.0**
Investment Cost		**$35 million**	
Annual CO_2e Reductions		**265,648 metric tons**	

A.2. Project Description

This group contains a small number of large, capital-intensive projects designed to reduce Anaerobic Digester Gas (ADG) leaks and use recaptured gas to power electric generation equipment. In the City's wastewater operations, methane is typically 65% of ADG produced; the remainder of ADG produced is CO_2, as well as other substances including particulate matter.

[22] This value reflects utility offsets.

B. *Retrofit Projects*

B.1. *Summary of Energy and Cost Savings*

WWTP Retrofits			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Electricity	(GWh)	42.0	$3.8
Natural Gas	(Therms '000)	38.0	$0.1
		TOTAL	**$3.9**
Investment Cost		**$43.3 million**	
Annual CO_2e Reductions		**20,145 metric tons**	

B.2. *Project Description*

Improvements to the following three major systems account for the majority of energy-saving measures identified: aeration systems, wastewater pumping, and dewatering operations. Among these three, aeration systems have the highest electricity consumption of all processes in WWTPs. The consultant based its savings projections for aeration systems on the implementation of measures to increase oxygen transfer efficiency and the installation of probes to monitor dissolved oxygen levels. Pumping system improvements identified include the installation of variable frequency drive controls. Additional savings may be available from dewatering system improvements such as the replacement of existing centrifuges with more energy-efficient ones.

2.3.9 New Construction

Efficiency improvements to new construction are expected to generate GHG reductions of 17,268 metric tons of CO_2e, or 1% of the total GHG reduction, as well as 1.4% of total investment cost and 1.6% of energy cost savings.

A. *Summary of Energy and Cost Savings*

New Construction			
		Annual Savings	
		Energy Units	Energy Cost ($Mil)
Electricity	(GWh)	42.0	$1.8
Natural Gas	(Therms '000)	1,071.0	$1.3
Oil	(Gallons '000)	588.0	$1.5
		TOTAL	**$4.6**
Investment Cost		**$32 million**	
Annual CO_2e Reductions		**17,268 metric tons**	

B. Project Description

Efficiency improvements to new construction consist of using highly energy-efficient equipment and design approaches that, when applied, will enable new buildings and major additions to significantly exceed the energy efficiency requirements of Local Law 86. Representative measures include:

- Reductions in lighting power density (watts installed per square foot) through use of best available technology;
- Expanded use of day lighting and related lighting controls;
- Increased insulation and optimal efficiency windows;
- Use of best available chiller technology in large buildings;
- Additional HVAC controls, including air and water-side economizers, demand controlled ventilation, heat recovery from exhaust; and
- Ultra-high efficiency gas boilers.

The Consultant estimated a 1.45% growth in new construction and assumed a 40% increase in energy efficiency over the New York State Energy Conservation Code standard.

2.3.10 Emerging Technologies and Trends

Over the next nine years, energy price increases, developments in renewable technologies, and an overall increase in the energy efficiency sector is expected to make a wider range of existing and soon-to-be-developed efficiency measures more cost-effective.[23] Application of these measures, which include solar thermal heating, displacement ventilation and fiber optic daylighting, is expected to account for at least 2.5%, or 41,889 metric tons of the GHG reduction total. In addition, we expect to see improved efficiency of our electricity power supply, which will also contribute to GHG reductions.

[23] Estimates of emissions reductions, implementation costs, or energy costs savings for particular types of measures in this category were not included in the financial analysis.

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3 Financial Impact of the Plan

3.1 Overview

The Consultant projected the financial impact of implementing the Plan on the City's budget using a net present value (NPV) approach typical for assessing the value of long-term public investments and programs. Specifically, the Consultant:

- Projected the cost to implement the program using a time period that captures the effects of long-term capital improvements installed throughout the life of the Plan (i.e., FY'17), as well as ongoing costs associated with enhanced O&M practices. The expected costs account for inflation in labor and construction costs, as well as the terms under which the City will borrow funds to finance capital improvements.
- Projected savings in energy costs to the City associated with the capital and O&M measures identified in Section 2 over the planning horizon. In addition to the physical units of energy saved, these projections include estimates of annual inflation in energy prices.
- Calculated the net costs or benefits each year over the planning horizon.
- Evaluated the stream of net annual costs or benefits using a number of approaches, including break-even cash flow and NPV.
- Conducted a sensitivity analysis to gauge the effect of sub-optimal and super-optimal changes in the assumptions of four variables on the overall NPV calculation, including the pace of inflation for energy and construction, as well as completion risk and performance risk.

3.2 Key Findings

The Consultant's base case analysis found that the Plan will yield an overall positive NPV of $625 million. Thus, the range of activities required to meet the GHG reduction goal will return significantly greater financial rewards to the City than if we keep the status quo. Additionally, the Plan will break even on an annual cash flow basis beginning in FY'13, and on a cumulative basis beginning in FY'15.

Furthermore, based on the sensitivity analysis conducted, the Plan's financial value is largely insulated from external price shocks. Performance risk appears to pose the largest potential threat to the value of the City's prospective efficiency portfolio. If actual energy savings realized per project fall 15% below the expected amount, on average, the NPV of the investments falls to $322 million, or 41% percent of the base case amount. In such a scenario, the City bears the full cost while receiving only 85% of the projected financial benefits through energy cost savings, further strengthening the argument for the effective measurement and verification of implementation.

3.3 Methodology

3.3.1 Base Case Cost Projections

The Consultant developed its cost projections using the methodologies that follow:

- ***Capital Expenditure Projections.*** The Consultant assigned an implementation schedule to each of the project groups shown in Figure 8 in Section 2.3. Every schedule contained a fraction of the total potential investment level for that measure group for each year from FY'08 through FY'17, with the fractions totaling to 1.0. The annual fractions reflected the Consultant's assessment of how quickly the City could advance projects, given its current level of experience and project management capacity. Total expenditures in FY'08 and FY'09 were limited to match the budget amount available, or $80 million and $100 million respectively. These amounts cover both capital and operating expenditures.
- ***Construction Cost Inflation.*** Annual construction cost inflation rates have remained at roughly 5% in recent years, due largely to worldwide shortages in construction materials. The Consultant has assumed that these rates will decline in future years and used a projected rate of 2.5% in its analysis, resulting in a 25% increase in construction costs over the duration of the Plan.
- ***Debt Service.*** The Consultant assumed that the Plan would be funded by the City's issuance of bonds, as opposed to using current-year operating revenues. The assumption is consistent with the definitions of eligible capital expenditures as defined by the Local Finance Law. With input from OMB, the Consultant assumed a borrowing rate of 5.5% and a bond term of 29 years. The capital expenditures projected for each year generated a 29-year stream of debt service payments. The sum of debt service payments from all active streams was used to represent debt service in a given year of the analysis.
- ***O&M Expenditures.*** As discussed in Section 2, the Consultant estimated that it will cost roughly $44 million per year in FY'08 dollars for the City to achieve appropriate energy-related O&M practices. The Consultant assumed that this will occur in even increments over the remaining nine years of the Plan. Increased O&M expenditures are treated as a current expense in the analysis. An annual inflation rate of one percent was applied to reflect increases in City labor costs.
- ***Program Administration Expenditures.*** The Consultant estimated program administration expenditures based on assumptions concerning staffing requirements for the project capital and O&M activities. Annual inflation rates of 1% for City labor and 2% for purchased services were applied to the stream of costs.
- ***Total Annual Spending.*** Total annual spending for each year in the analysis equaled the sum of program administrative expenditures, O&M expenses, and debt service for that year.

3.3.2 Base Case Savings Projections

The Consultant developed its savings projections using the methodologies that follow:

- ***Energy Savings in First Year of Implementation.*** Total potential energy savings for each project group, disaggregated by fuel, was allocated to the 10 years of the program period using the implementation schedules discussed above.
- ***Life Cycle Energy Savings.*** The Consultant assigned an effective useful life (EUL) to each measure group based on studies of the persistence of savings from various kinds of energy efficiency measures. These EULs ranged from seven years for retro-commissioning to 20 years for improvements to heavy equipment and new construction. The Consultant next assigned decay functions to the measure groups, again based on measure retention and persistence studies. For example, the decay function assigned to replacement and retrofit measures reduces the savings produced in even annual steps to 90% in the ninth year after implementation, then to 50% in twelfth year, the last year of the EUL. No more savings are claimed for that group of measures thereafter.
- ***Annual Energy Savings.*** The Consultant estimated annual energy savings for all measures assumed to be functioning in a given year by fuel. This was accomplished by summing the "decayed" annual savings for each annual cohort of projects implemented by project group.
- ***Value of Energy Savings/Energy Price Inflation.*** The Consultant next applied an inflation-adjusted fuel cost to total annual savings for each fuel to estimate the annual value of savings. OMB develops five-year fuel inflation rates for use in its own budgeting and financial projections, which are based upon the terms of negotiated electricity purchase contracts and on market price projections prepared by outside economic consultants. The Consultant used these annual rates for inflation figures through FY'12. For years after FY'12, the base case specified annual inflation of 3% for all fuels.

3.3.3 Assumptions in Net Present Value Calculations

- ***Planning Horizon.*** The Consultant used a 25-year planning horizon, spanning from FY'08 through FY'32 for the analysis.
- ***Discount Rate.*** Following the guidance of OMB, the Consultant used a discount rate of 5.5% per year, which is equal to the City's borrowing cost.

3.4 Sensitivity Analysis

The Consultant conducted a sensitivity analysis to assess the results of the financial analysis with respect to various risks that could affect the budget impact of the program. Specifically, the Consultant tested the effect on the NPV of the following four risk areas.[24]

[24] The sensitivity analysis treated each risk area individually; the impact of multiple risks was not compiled.

- ***Energy price inflation.*** If energy price inflation is higher than assumed, the value of energy savings will be greater, leading to an increase in the NPV of program implementation. Similarly, if energy price inflation is lower than assumed, the NPV will be lower. To test the effect of variation in this assumption, the Consultant set the lower case at the base case assumption *less* 20%. The higher case was set at the base case *plus* 20%. Thus, the tested values were: (i) Lower Case = 2.4% annual inflation; (ii) Base Case = 3.0%; and (iii) Higher Case = 3.6%.
- ***Construction price inflation.*** If construction price inflation is higher than assumed, capital costs and debt service will increase, leading to a decrease in the NPV. The tested values were: (i) Lower Case = 2.0%; (ii) Base Case = 2.5%; and (iii) Higher Case = 3.0%.
- ***Completion risk.*** Capital intensive projects face various obstacles to completion, such as delays or cancellations, which lead to further increased costs due to inflation. The effects on the NPV are further magnified because the program incurs operating costs whether or not the projects are completed on time. In this case, the Consultant specified only a low case, since the probability of completing a larger number of projects than specified in the 10-year time period is very low. The tested values were: Lower case = base project completions *less* 15%.
- ***Performance risk.*** Measurement and verification studies of energy efficiency programs targeting commercial and government customers have found a large variation in the gross realization rate, or the percentage of expected energy savings actually achieved and verified. The gross realization rate can range from 75% on the low end to 110% on the high end. The gross realization rates for programs that support fairly simple types of measures, such as lighting and motor replacement, tend to cluster in the range from 90% to 100%. Programs involving custom measures generally experience a wider range in realized savings, due to the more heterogeneous nature of the measures installed and the generally smaller number of projects completed. In this case, the Consultant specified the following test values: (i) Low Case = 85%; (ii) Base Case = 100%; (iii) High Case = 105%. Figure 11 displays the NPV for each of the scenarios described above.

Figure 11: Results of Sensitivity Analysis: NPV in FY'08 ($millions)
Base case NPV = $625 million

Risk Factor	Scenario Definition	
	Base Case -20%	**Base Case + 20%**
Energy Price Risk	$505	$772
Construction Price Risk	$727	$591
	Base Case -15%	**Base Case + 5%**
Performance Risk	$271	$789
Completion Risk	$559	n/a

These results can be summarized as follows:

- ***Effect of energy price risks.*** If energy price inflation runs 20% less than assumed, the NPV of long-term energy savings will be $505 million, or 23% less than the base case. The reason for the difference is that fewer measures will be cost effective at lower energy costs. If energy price inflation runs 20% higher than expected, the NPV of the energy efficiency investments will be 17% higher than the base case. The reason for the asymmetry in this effect is that most cost-effective measures already have been accepted into the portfolio in the base case.

  Challenge: Energy prices shocks are largely outside the control of the City.

- ***Effect of variance in construction price inflation.*** A change of ± 20% in the rate of construction inflation results in a symmetrical change of ± 10% in NPV.

  Challenge: The cost of construction is largely outside the control of the City.

- ***Effect of completion risk.*** The change in NPV associated with a reduced pace of project completion is proportional to the reduction in the percentage of projects completed. A 15% slowdown in projects completed results in an NPV that is 15% lower than the base amount.

  Mitigation Strategy: The City should ensure that projects are adequately scoped and that costs are adequately estimated at the beginning of the process to avoid unrealistic timelines and reduce the likelihood of cost escalations.

- ***Effect of performance risk.*** Performance risk poses the largest potential threat to the value of the City's prospective energy efficiency portfolio. If actual energy savings per project falls 15% below the expected amount, on average, the NPV of the investments will fall to $271 million, or 41% of the base case amount. Computationally, the reason for this result is straightforward. In such a scenario, the City bears the full costs while receiving only 85% of the projected financial benefits.

  Mitigation Strategy: By incorporating an effective measurement and verification system in the Plan (as proposed in Section 4.3.4), the City will be able to identify projects that tend to underperform in comparison to their modeled savings. If these underperformances are found to be the product of poor project implementation, the City can take steps to manage these projects more effectively. If the underperformances are instead due to overly optimistic modeling, the City can adjust expectations for future projects of that type.

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4 Implementing the Plan

Section 4 provides the Steering Committee's recommended approach to implementing the Plan. To meet its GHG reduction goal, the City will need to coordinate and finance an aggressive program that includes over $2.3 billion of energy efficiency projects–approximately $1.9 billion in capital upgrades and $400 million in operating expense funded activities–which are identified in Section 2. The successful implementation of these projects will require all City agencies to enhance their current capacity to identify and complete an extensive portfolio of projects that vary in size, scope, and technical sophistication. In addition, the City must take significant steps to improve O&M practices and other related activities across agencies.

4.1 Capital Projects

4.1.1 Capital Project Portfolio

Figure 12 illustrates the capital project portfolio required to achieve the GHG reductions detailed in Section 2. Figure 12 also includes the Steering Committee's assessment on the level of program management required to implement typical projects in each category and estimates of the risk levels associated with their successful implementation, as explained below.

- ***Project Management Level.*** Project management level refers to the technical background and time required to manage a single project. For example, an elevator motor replacement will have low project management requirements, while a BMS installation will require significantly greater project management.
- ***Completion Risk.*** Completion risk refers to the uncertainty of site and market conditions and their impact on the successful completion of a project. Characteristics of projects with high completion risk include those: (i) where the physical conditions of a site cannot be fully assessed until work actually begins; (ii) which require major changes to energy management systems in existing buildings; (iii) that have long lead times or uncertain construction costs; or (iv) require regulatory approvals. Cogeneration projects, for example, are susceptible to completion risk.
- ***Performance Risk.*** Performance risk refers to the uncertainty of energy savings that a project will actually realize once it is completed. High performance risk is often associated with projects that use relatively new technology or rely on continued operator intervention to achieve savings. Lighting and HVAC equipment replacement projects have low performance risk, while distributed generation projects, building management system installations, and retrofits to wastewater treatment plants have high performance risk.

Figure 12: Projected Capital Project Portfolio[25]

Project Type	10-Year Total to Complete	Range (FY'08 '000)	Average Cost ('000)	Level of Proj Mgt Required	Completion Risk	Performance Risk
Existing Buildings: Equipment Replacements, Retrofits, and Other Capital Improvements						
Equipment Replacements	365	$200 - $1500	$500	---	---	---
Retrofits	1,432	$250 – 2,500	$700	○	○	---
Oil Boiler Conversions	100	$600 - $1,300	$750	○	○	---
Advanced BMS	50*	$300 – $5,000	$1,300	◉	◉	◉
Data Centers	17	$100 – $1,000	$500	◉	○	○
Street Lighting						
Street Lighting	11	$300 – $5,000	$3,000	○	---	---
Clean Distributed Generation						
Combined Heat & Power	30	$300 – $5,000	$3,300	◉	◉	◉
Solar Photovoltaic	10	$2,200 – $5,200	$3,700	◉	○	○
Wastewater Treatment Plants						
Retrofits, Methane Capture & Generation	16	$2,000 – $10,000	$5,000	◉	○	◉
New Construction						
New Construction**	116	$50– $5,000	$100	○	○	○
Operations & Maintenance Program						
Retrocommissioning	50	$100 - $350	$250	◉	○	○
Grand Total	**2,197**					

* Encompassing up to 160 buildings.
** Incremental compared to standard required by Local Law 86.

◉ = High, ○= Medium, --- = Low

[25] The number of projects in each category was estimated by dividing the total costs for the measure group (generated by the energy savings analyses described in Section 2) by the average project costs shown in Figure 12. Although vehicle efficiency upgrades constitute capital improvements, they are not included in this chart because they do not require the same type of project development and management effort required of projects in buildings and other stationery facilities. We also have not estimated the number of emerging technology projects since they have not yet been detailed.

Figure 12 also highlights the following two key points:

- ***The City must significantly increase its level of project activity.*** To implement the portfolio of approximately 2,200 projects shown in Figure 12, the City must significantly increase its project management activities and committed resources. From January 1998 to December 2007, the City completed 278 projects through the ENCORE Program, with an inflation-adjusted value of $306 million. The majority of ENCORE projects involved equipment replacements and retrofits. By 2017, the City will need to complete an estimated 1,800 projects in these categories alone, with an estimated construction value of $1.18 billion, representing an eight-fold increase in the number of projects and a four-fold increase in the amount of funds. Moreover, the City will need to complete over 400 considerably more complex projects involving distributed generation, retrocommissioning, and advanced BMS installations.
- ***The City's projects are segmented.*** Each of the 11 project types identified in Figure 12 fall into one of two categories, specifically, those with high volume and low project management demands, or those with low volume and high project management demands.

4.1.2 Current Practices, Existing Challenges, and Next Steps

The following summarizes current agency practices and challenges with respect to each of the energy efficiency project types identified in Section 2, and includes the Steering Committee's next steps for each.

A. Existing Buildings: Equipment Replacements, Retrofits, and Other Capital Improvements (45% of total GHG reduction)

The identification of opportunities for GHG reductions in facilities and operations is generally led by an agency's capital planning or engineering division. These identification efforts vary greatly from agency to agency. Additionally, energy system enhancements most often occur as part of an agency's overall capital renovation program, as opposed to an initiative specific to energy conservation. Those agencies opting to complete projects for the specific purpose of conserving energy generally rely on the project management services provided by DCAS as part of the ENCORE Program.

Several key challenges exist with respect to expanding the development of projects in existing facilities, which again account for the greatest number of projects in the portfolio. The challenge most often cited by agency managers interviewed by the Consultant was the limited amount of project management capacity and resources. The Consultant also found that agencies often focus their capital project management activities primarily on compliance with codes and regulations, which are often only a component of best practices.

Additionally, facility managers expressed a limited familiarity with newer energy saving measures, such as retrocommissioning and newer BMS technologies, which offer a more holistic and cost-effective approach to conserving energy. Consequently, rather than

using a "full-building" approach, agency facility managers generally implement energy efficiency measures in piecemeal fashion.

As noted in Section 1.2.8, under the FY'08 short-term action plan, DCAS and DDC conducted pilot projects to examine the benefits of using "full-building" audits and LEED-EB/retrocommissioning as a tool to identify energy conservation measures within existing facilities. The DCAS pilot commissioned energy audits for 22 City-owned buildings, which were specifically chosen to represent the full diversity of the City's building inventory in terms of size, use, location, and vintage. The audits included inspections of the facilities, interviews with the facility operations personnel, energy modeling, and retrocommissioning. The LEED-EB/retrocommissioning pilot studied 10 City-owned buildings to assess the potential costs, energy savings, and other benefits associated with the adoption of LEED-EB standards and stand-alone retrocommissioning.

Next Steps. To expedite capital project identification and development in existing buildings, which account almost half of all estimated GHG reductions, the Steering Committee will need to perform the following activities:

- ***Enhance energy efficiency project management capacity at agencies.*** The Steering Committee will work with the largest energy-using agencies to develop the project management capabilities necessary to effectively identify and manage GHG reduction projects. The Steering Committee will work with agencies to address current resource limitations, including staffing, and develop guidance documents to direct facilities managers on the range of typical energy efficiency measures available, including their basic operation, costs, savings estimates, and risk factors associated with successful installation and operation.
- ***Further explore additional procurement opportunities to expedite the bidding and contracting processes.*** Given the scale and scope of the projects identified, the Steering Committee will explore the availability and applicability of additional procurement opportunities to expedite bidding and contracting for capital project development and implementation.
- ***Expand on the FY'08 full building audit and LEED-EB/retrocommissioning assessment pilots.*** The Steering Committee will conduct the efficiency measures identified through the audit process, and expand on the "full-building" audit pilot by identifying additional facilities for inclusion in the program. Additionally, the Steering Committee will develop a list of typical, recommended efficiency projects for the representative facility types included in the pilot. With respect to the LEED-EB/retrocommissioning pilot, the Steering Committee will implement the cost-effective energy efficiency measures identified and continue to assess the role of additional LEED-EB/retrocommissioning assessments going forward.
- ***Conduct pilot deployments of advanced BMS to characterize their capabilities and identify factors that contribute to successful applications.*** As discussed in more detail in Section 4.3.3, the Steering Committee will install advanced BMS in one or more facilities as part of the broader initiative to implement metering and monitoring.

B. Street Lighting (3% of total GHG reduction)

DOT is implementing a street lighting upgrade program to replace street lighting in every borough over the next three years. Phase one is currently underway for Queens and Brooklyn, with approximately 30,000 lights already replaced. Once the first phase is completed, DOT will begin the second phase to replace lighting throughout the Bronx, Manhattan, and Staten Island, which is expected to be completed over the next three years.

Next Steps. The Steering Committee will coordinate with DOT to complete this effort and review new street lighting opportunities as appropriate.

C. Clean Distributed Generation (4% of total GHG reduction)

The City has limited experience in the area of combined heat and power (CHP) and solar photovoltaic (PV) projects. For instance, the City has completed a CHP project at the Bronx Zoo and is currently implementing one on Rikers Island. Additionally, solar PV installations have been completed in several City buildings, and the City has released a RFP for the development of solar PV installations with a capacity totaling two megawatts.

The Steering Committee estimates that approximately 30 CHP and 10 solar PV projects will need to be completed to successfully capture the 3.9% of the total GHG reduction potential identified. While the number of projects is comparatively low, these projects face a unique set of challenges, including regulatory permitting, detailed site engineering, negotiation of interconnection and standby power agreements, and highly technical installations.

Next Steps. The Steering Committee will work with agencies to identify additional cost-effective CHP opportunities and will assist agencies in addressing the technical and regulatory challenges identified above. These opportunities likely will extend across a large number of agencies, and as a result, will require effective, coordinated guidance and planning. The Steering Committee will continue to monitor progress on the solar PV RFP and proposed installation of the initial portfolio of buildings, and will subsequently make recommendations on additional sites.

D. Wastewater Treatment Plants (17% of total GHG reduction)

DEP has commissioned various studies of energy efficiency and methane capture projects at its wastewater treatment plants. At many of these facilities, the current ADG piping infrastructure has passed its recommended useful life and requires repair or replacement. While DEP conducts regular repair and maintenance to comply with regulatory codes, additional resources are necessary to more quickly realize the significant GHG reduction potential from improvements to wastewater treatment plants.

Next Steps. Savings from currently-identified improvements to wastewater treatment plants are estimated to yield 17% of the total GHG reduction potential identified. These reductions will be achieved through a small number of large, capital-intensive projects: eight projects to improve the energy efficiency of aeration and other processes; three

projects to replace ADG gas piping with stainless steel piping; four projects to install microturbines for cogeneration; and one project to repair digester roofs and gas holding tanks at the Bowery Bay facility.[26] The Steering Committee will work with DEP to begin the development of a detailed schedule for the projects described above, and also will work with DEP to create a broader strategy that ensures that emissions levels across its facility portfolio are actively managed going forward.

E. Vehicles (5% total GHG reduction)

A number of City agencies, such as DSNY, DCAS and DPR, with large fleet operations have initiated significant efforts to upgrade the efficiency of their vehicles. Both agencies also assigned a senior administrator to manage fleet operations, which includes identifying and implementing measures to reduce fuel use, such as purchasing hybrid vehicles, as well as smaller vehicles to replace light duty trucks and SUVs, and retrofitting diesel engines to burn low sulfur fuel. Efforts to monitor fuel use and to reduce vehicle miles traveled are less advanced.

Next Steps. The Steering Committee will build on City agencies' past and present fleet upgrade efforts by providing additional financial support, technical resources, and planning oversight. In addition, the Steering Committee will lead the following efforts:

- ***Light-duty hybrid adoption.*** The City has been a leader in the adoption of light-duty hybrids such as the Toyota Prius. In the near-term, the City should continue to purchase hybrid sedans and SUVs for its fleet whenever possible, as hybrid models achieve up to 50% higher fuel economy and significantly lower emissions than their non-hybrid counterparts.
- ***Fleet transition planning.*** The Fleet Consultant has developed a draft plan outlining a phased adoption of vehicle technologies and vehicle use reduction for each agency to realize GHG reduction goals. The next step will require agency development of more detailed tactical plans that include vehicle procurement and retirement schedules, changes to fueling infrastructure, modifications to maintenance procedures, reductions in vehicle miles traveled (potentially involving overall fleet reduction), and right-sizing vehicle types to operational requirements. These tactical plans will detail cost and budgetary requirements for meeting the City's reduction goals.
- ***Cross-agency technology pilots.*** In most cases, agencies have acted independently in their pursuit of new vehicle technologies and alternative fuels. This has affected both the type of vehicle technologies that have been adopted as well as the scale of the pilot projects. The Fleet Consultant has identified a number of key technologies, including light-duty electric vehicles, cellulosic ethanol, and heavy-duty plug-in hybrid vehicles, that the Steering Committee plans to pilot across multiple City agencies. These pilots will offer agencies valuable experience with new technologies, and will prepare the City's fleet for

[26] Due to the insufficient information on the thermal loads of the four identified plants, the CO_2e savings represented in our report do not count the savings from thermal energy (hot water) generated by ADG powered cogeneration facilities.

wider adoption of these emissions-reducing vehicles and fuels upon becoming more widely available.

- ***Overall cross-agency coordination.*** This effort will require agencies to work together to share best practices and lessons learned for vehicle technologies and fuels, including evaluating vendors and developing procurement strategies. In its current role of fleet oversight and coordination of Citywide vehicle procurement, DCAS is well-positioned to ensure that agencies develop transition plans and coordinate with other agency fleets to execute those plans. The Steering Committee will work with DCAS to continue providing agencies with technical support in these areas.

F. New Construction (1% of total GHG reduction)

As described in Section 1.2.4, LL 86 mandates that all City-funded capital projects with a construction cost of $2 million or more be designed and constructed to achieve LEED Silver or higher rating, or for educational and healthcare institutions, a LEED Certified or higher rating. In addition, the law requires projects with construction costs of $12 million or more to reduce energy costs by 20% to 30% percent below the American Society of Heating, Refrigerating, and Air-Conditioning Engineers standard (ASHRAE 90.1 1999) or the New York State Energy Conservation Code standard, whichever is more stringent. Other energy cost reduction requirements include those for projects not subject to LEED certification requirements that involve installation or replacement of boilers, lighting systems, or heating, ventilation and air conditioning controls. Agencies are also required by LL 86 to report annually to the City Council in accord with a reporting procedure and format that is being developed by DDC in conjunction with the Mayor's Office of Environmental Coordination.

Next Steps. The Steering Committee fully supports the overarching goals of LL 86 and will seek to incorporate its requirements with the project selection process, performance measurement and verification, and data collection initiatives introduced under this Plan. In doing so, the Steering Committee will help ensure that projects follow the same standards regardless of their funding source or programmatic purpose. In addition, the Steering Committee will explore opportunities to further enhance LL 86 as technologies and standards change going forward, as well as review opportunities to expand the range of facilities covered by the law to include partial renovations and several other occupancy groups or building types currently not covered.

G. Emerging Technologies and Trends (2% of total GHG reduction)

There are a variety of emerging technologies in the energy efficiency sector, and we expect to see the continued development of cost-effective GHG reduction measures over the next nine years. Generally, the City has been proactive in piloting new technologies (e.g., biofuels,[27] geothermal heating, solar PVs, and daylight harvesting). We expect

[27] Recent research has raised questions about the overall impacts of biofuel on GHG emissions and on food supplies. Currently, both the U.S. Environmental Protection Agency and the California Air Resources Board are developing standards for biofuels that will not have negative effects and it is anticipated that the City will adopt one of these standards.

several existing technologies to soon become more commercially and economically available including, displacement ventilation, solar thermal energy, thermal scan technology, mixed mode ventilation, and green walls. Additionally, we expect improvements to our electricity supply infrastructure to contribute to GHG reductions over the next nine years.

Next Steps. The Steering Committee will continue to monitor developments in new technologies and take full advantage of cost-effective applications as they arise.

4.1.3 Capital Project Selection

A. *Overall Portfolio Criteria*

In addition to projects identified through audits and retrocommissioning, the Steering Committee will assign priority to projects that meet the following criteria:

- ***Projects that are cost-effective.*** The Plan will maximize to the extent possible the advancement of projects that offer a positive financial return on investment.
- ***Projects that can be replicated in numerous facilities with relatively little site-specific engineering effort.*** For example, boilers in firehouses that were built in the same time period.
- ***Projects that address defunct or badly outmoded control systems.*** The recommended application of retrocommissioning and preventive O&M practices require that lighting, HVAC, and other building controls be functional and effective.
- ***Projects that address multiple building systems, such as lighting and HVAC.*** By encouraging facility managers to address multiple systems in replacement and/or retrofit projects, the City will yield gains in time and expense and minimize disruption to facility occupants and service delivery.
- ***Projects that contribute to peak load reductions.*** As discussed in Section 2.2.4, reductions in peak electric demand will produce significant financial benefits for the City, as well as contribute to increased electric system reliability and improved air quality conditions. Energy efficiency projects that address end-uses coinciding with summer peak hours will generate the greatest contributions to peak load reduction. These end-uses include air conditioning, ventilation, and lighting in facilities with year-round occupancy.
- ***Projects characterized by long development cycles and large potential GHG reductions.*** These include methane containment and cogeneration projects at wastewater treatment plants, cogeneration projects at existing buildings, and advanced BMS. These projects have 1- to 2-year development cycles, and beginning these projects early will help the City develop the technical experience required to complete a significant number of projects by 2017.

B. Individual Project Selection Criteria

The Steering Committee will apply the following criteria to select projects eligible for annual appropriations, in conjunction with the overall portfolio criteria above:

- Estimated annual and life cycle energy savings;
- Estimated annual and life cycle emission reductions;
- Estimated contribution to peak load reductions;
- Cost per life cycle unit of energy saved;
- Cost per life cycle ton of emission reduced;
- Overall cost-effectiveness;
- Adequacy of documentation for estimated costs and savings; and
- Adequacy of documentation for the availability of resources required to complete the project.

C. Individual Project Application Process

Given the increased volume of project applications that will need to be processed and reviewed, the Steering Committee will create a rapid application and approval process. Specifically, the Steering Committee will explore application processes developed by utilities and other agencies that conduct large-scale energy efficiency programs. These organizations have developed systems that balance the customer's ease of use with the requirements of accountability for the use of public funds. Program operators generally divide their customer-oriented programs into two administrative categories, including:

- ***Standardized projects.*** These projects include replacement and retrofit projects for lighting, HVAC systems, motors, variable frequency drives and refrigeration equipment, and often consist of one-for-one replacement of older equipment with high-efficiency models with pre-approved specifications. Applications for these projects generally require a project initiator to enter the type and quantity of equipment to be replaced, along with information on the type, size, and operating hours of the facility, the latter being required to produce a preliminary estimate of energy savings associated with the project. The application also often requires information on project pricing and identification of the engineers and contractors involved. Such information can be used in conjunction with the selection criteria described above to assist in evaluating project proposals, as well as form the basis of records needed to track projects for completion, estimation of program level energy savings, and sampling for monitoring and verification of savings.
- ***Customized projects.*** The majority of other project types in the portfolio will require more detailed facility-level studies to assess feasibility, costs, and project savings. Given the greater complexities associated with these projects, the Steering Committee will require applicants to provide the following additional information:
  - Facility identification and uses;

- Current energy consumption and peak electric demand;
- Description of measures to be installed, including detail on capacity, efficiency ratings, controls, and other performance-related details;
- Estimate of project costs, including documentation of assumptions and methods used in the estimate;
- Estimate of annual energy savings and peak load reduction, including documentation of assumptions and methods used in the estimate; and
- Identification of the project manager for the agency and key vendors.

The Steering Committee will develop project assessment templates for standardized and customized projects to assess the likely financial and GHG reduction potentials for each proposal.

4.2 Operations and Maintenance

As discussed in Section 2.3.3, the Consultant conducted a preliminary analysis of O&M practices at five of the City's largest energy-using agencies, as well as a review of industry reports on other documentation of best practices in facility management.[28] The Steering Committee is using the Consultant's assessments as the basis for its approach to improve current O&M practices in the City's buildings, as well as within its vehicle fleet.[29] While the O&M studies will not be fully completed until later this year, preliminary recommendations are listed below.

4.2.1 Existing Buildings

Preliminary recommendations on measures to enhance O&M practices in City facilities include:

- ***Provide additional training to maintenance and facility management personnel.*** To be effective, current and newly hired maintenance and facility management personnel will need additional training on how to recognize and address energy-related maintenance needs. While it will vary somewhat according to the nature of the facility and equipment, training generally will include the recognition of both general issues, such as energy consumption monitoring, and specific issues, such as the proper operation and maintenance of particular pieces of equipment.
- ***Increase preventive O&M and define protocols.*** As discussed in Section 2.3.3, agencies must employ a preventive O&M approach for key energy systems, such as heating, cooling, and lighting. These preventive measures include monitoring the condition of critical systems on a regular basis.
- ***Enhance O&M management systems.*** The application of preventive O&M procedures requires the development of systems that schedule and monitor the

[28] Departments of Correction, Citywide Administrative Services, Education, Sanitation and Environmental Protection.
[29] AECOM Technology Corp. and KEMA Inc. study for O&M practices; Booz Allen Hamilton study for vehicle fleet.

results of those activities. Given the scale of the facility inventory managed by the City's larger agencies, the management of preventive maintenance activities likely will require the development of new computerized systems.

- ***Review and expand maintenance contracts to ensure accessibility and best practices.*** O&M best practices for major mechanical systems such as packaged HVAC units, chillers, boilers, and other distribution systems change over time. Recent examples include the development of instrumented diagnostics for the efficiency of packaged HVAC equipment and applications of thermography and vibration analysis for boiler and pump operations. Maintenance contracts therefore should be written to ensure that vendors are incorporating current best practices into the services being provided. The need for additional maintenance contracts to facilitate improved levels of service also will be prioritized.
- ***Improve coordination with capital planning and engineering.*** Currently, mechanical system installations lack standardization across City agencies. The selection of high-efficiency models for such equipment and the standardization of specifications will reduce maintenance costs and energy use. Examples include electric motors, lighting fixtures, and packaged HVAC equipment.
- ***Add maintenance personnel and supervisors, where appropriate.*** As discussed in Section 2.3.3, the City must hire a significant number of additional skilled maintenance personnel and supervisors, as well as reevaluate the tasks and standards employed by existing personnel, across its agencies in order to deliver improved O&M services.

4.2.2 Vehicles

As discussed in Section 2.3.6, City agencies with the largest vehicle fleets are already conducting a variety of O&M practices to increase fuel efficiency and reduce GHG emissions. These measures include inflating heavy truck tires with helium and/or nitrogen to reduce leakage, as well as the use of various biofuel blends. The following vehicle fleet O&M best practices should further cut fuel consumption and GHG emissions:

- ***Fleet and/or mileage reductions.*** Several limited opportunities exist for reducing the number of vehicles in the fleet or for reducing vehicle miles traveled (VMT). These opportunities often involve implementing stricter policies on the use of City vehicles.
- ***Implementation of better fuel monitoring and accounting.*** The majority of City agencies lack a fuel accounting system that is accurate and reliable enough to monitor overall fleet fuel use in a timely matter or to track fuel use on a vehicle-by-vehicle basis. A comprehensive citywide fuel monitoring system with appropriate incentives can yield a significant GHG reduction, estimated to total as much as 5%.
- ***Implementation of vehicle tracking technologies.*** A variety of technologies are currently available for tracking vehicle use. These technologies generally use GPS systems to monitor and record vehicle location, and vary in terms of

sophistication, costs, and reporting capabilities. Several municipal agencies across the country have implemented such technologies for their vehicle fleets, with mixed results; for instance, several cities have reported as much as 15% lower VMT, while other cities have experienced almost no change in VMT.

- ***Coordination of agency planning and implementation efforts.*** In the next nine years, each City agency must plan and manage the transition of its vehicle fleet to meet the City's GHG reduction goal. Such an effort will include the development of tactical vehicle procurement and retirement plans, analysis of new propulsion systems and alternative fuels, and evaluation of vehicle/fuel providers. Through DCAS, the Steering Committee will provide a central source of expertise for City agencies, offering vehicle research and draft product specifications, tracking annual progress of vehicular GHG reductions, and assisting in the management of additional vehicle procurements required.

4.3 Key Support Activities

To implement the full range of large-scale, diverse, and complex projects (capital and O&M) highlighted above, the Steering Committee will pursue the following key activities:

4.3.1 Coordination and Support for Agency Activities

As discussed in Section 4.1.2, the Consultant found that agency efforts to reduce energy costs, energy use, and GHG emissions are generally decentralized and often not the primary focus of the staff assigned to manage these efforts. For the most part, agencies conduct energy-related improvements in the context of broader capital projects, with the exception of the ENCORE projects, most of which are funded outside of the agencies' capital budgets. While the ELO network provides some support and coordination for agencies, the scope and scale of projects necessary to meet the City's GHG reduction goal require greater coordination, support, and a more integrated approach to energy use management and resource allocation at the agency level.

Next Steps. In order to meet the City's reduction goal, agency heads will need to play a leading role in organizing energy efficiency efforts within their respective agencies. As such, the Steering Committee will work with agencies to ensure that they possess the staffing and resources necessary to assist them. The Steering Committee will promote regular reporting of agency energy use, and expand the existing ELO network as a forum for training, information sharing, and ongoing support for energy-related projects conducted by agencies. Additionally, the Steering Committee will work with agencies to:

- ***Define an accountability framework.*** Within this framework, agency heads will be held responsible for the performance of their agencies' energy efficiency program, as well as the overall level of energy consumption within their agency.
- ***Expand the ELO role from one staff member to several, where feasible.*** The Steering Committee will work with larger agencies to expand the ELO role from one staff member to several in various agency departments.

- ***Expand training sessions.*** The Steering Committee will develop training sessions for ELOs and other staff to cover relevant topics, such as: how to run a simple facility energy audit and identify energy-saving opportunities in a building; how to estimate the energy-saving potential of building retrofit projects and incorporate those estimates into capital budget requests; and how to benchmark facility energy use and measure and evaluate project results toward program goals.

4.3.2 Building Performance Tracking and Information Management

The collection and management of energy consumption, cost, and efficiency information at the facility level will enable the City to best use program resources. Currently, the City compiles and maintains a variety of databases that contain key information related to the overall reduction of GHG emissions. In addition to the DCAS energy bill database discussed in Section 1, other City databases include the following:

- ***Asset Inventory Management System (AIMS)***. Developed and maintained by OMB, AIMS contains basic information about the majority of the City's buildings, including agency names, addresses, uses, number of stories, year constructed, and year renovated. AIMS also captures the results of periodic surveys of key building systems.
- ***Local Law 86 of 2005 database***. This database includes the scope of renovations and new construction, the investment cost and energy cost savings associated with energy and water reduction measures, and the projects' U.S. Green Building Council's Leadership in Energy and Environmental Design certification status.
- ***Local Law 1 of 2007 database***. This database includes assessments for all buildings with a peak load of 500 kW or greater for the feasibility of installing a clean distributed generation system.
- ***Oil and vehicle fuel consumption databases***. Individual agencies compile billing information for fuel oil delivered to their facilities. These bills are provided by delivery route and are not disaggregated by building. Several agencies also maintain databases on vehicle fuel use.
- ***Building Condition Assessment Survey (BCAS)***. Developed and maintained by DOE, BCAS captures detailed data on public school buildings, including mechanical, electrical, and architectural information, as well as the results of yearly surveys of key building systems.

While these databases generally contain high-quality, current data, the systems are not designed to monitor energy consumption, capital project planning and implementation, and enhanced O&M activities at the facility level, as will be required to meet the GHG reduction goal.

Next Steps. The Steering Committee has developed a RFP for a comprehensive building performance database to be released in the summer of 2008. The new system will link information from existing databases, as well as from new data collection efforts, and will enable users to analyze energy use and cost information at the facility level, as well as

support various benchmarking software programs (e.g., U.S. EPA Energy Star Portfolio Program). The facility-level items will include the following:

- Energy consumption and cost, including monthly demand data;
- Facility attributes, such as principal building uses, square footage, number of stories, type of heating equipment, type of cooling equipment, and presence of elevators or escalators; and
- Energy efficiency project information, including scope, agency staff involvement, project status, estimated and actual costs, estimated energy savings, and verified energy savings.

4.3.3 Application of Advanced Metering and Monitoring Technology

The City currently relies on its energy suppliers to provide compiled consumption data as part of the billing process. Over time, the City and its energy suppliers have developed systems that work smoothly for this purpose and yield accurate data; however, receipt of the data occurs well after the consumption occurs. Moreover, once data is received, it must be consolidated at the facility level and analyzed before it can provide useful information for targeting energy conservation or O&M efforts.

Recent advances in digital control, data communications, and building data analysis technologies have led to the development of automated BMS that offer significantly greater functionality at a lower cost than their predecessors. Applications of these technologies fall into the following two broad categories:

- ***Energy Information Systems (EIS)***. These systems gather and analyze energy use data from building-level and/or end-use level meters to provide facility managers with time-series information on energy use and electric demand at intervals as short as five minutes. Such systems may be deployed in single buildings, campuses, or groups of geographically dispersed facilities. For example, the New York State Office of General Services (OGS) has installed an EIS that gathers data from electricity, gas, water, and oil tank meters from 52 large State facilities. OGS has used the system to identify cases in which energy consumption did not correspond to known patterns of facility occupancy. In a number of cases, OGS was able to inform facility managers of HVAC systems that were running while their building was unoccupied, leading to significant energy savings. OGS has also used data developed through the system to identify and assess the potential financial effects of energy-related capital improvements and participation in demand response programs sponsored by the New York Independent System Operator.
- ***Energy Management and Control Systems (EMSC)***. Energy Management and Control Systems combine the remote metering capabilities of EIS with two-way communication and remote control of end-use equipment. Using such systems, analysts and operators at a central location can monitor equipment operation and energy use in connected facilities and control individual devices to reduce energy use and electric demand. For example, the University of Pennsylvania is

currently installing an EMSC in clusters of buildings on its Philadelphia campus. The electric and gas meters in each building are monitored continuously as are 10 to 15 end-use devices. The building-level sensors and meters are linked to a central facility via wireless communication technology. The University intends to use this system to identify energy savings opportunities, increase the level of ongoing control over end-use devices, and facilitate participation in demand response programs.

As discussed in Section 2.3.2, large City buildings are often equipped with BMS; however, these systems are generally outdated. It is likely that it will be more cost-effective to replace these systems, or at least their central processing units, than it will be to repair and re-commission them.

Next Steps. The Steering Committee will issue a RFP for technical research and pilot installations to explore the value and risks associated with currently available approaches to metering and monitoring of facility operations. The expected release date for the RFP is summer 2008. The RFP will solicit services from expert consultants familiar with the current state of technology and local regulation to assist with the following:

- ***Identify potential business cases for applications of advanced metering and monitoring technologies in groups of facilities within the City's building inventory.*** These business cases will take into account the specific features of the facilities, their patterns of use, levels of staff capability, and trends in energy prices, as well as trends in state and federal regulation concerning utility obligations to provide metering technology to customers.
- ***Specify pilot projects designed to test the proposed business cases.*** The pilot plans will identify the types of facilities to be included, the desired functions of the metering and monitoring system, the mechanism by which data from the metering and monitoring system will be used to achieve energy savings, and the criteria by which the results of the pilot will be assessed.
- ***Implement pilot applications.***

The Steering Committee will use the results of these pilot projects to decide on a broader implementation strategy.

4.3.4 Performance Measurement and Verification Program

In order to meet the City's GHG reduction goal, the effective measurement and verification of savings generated by projects is required because the performance of efficiency measures is subject to a number of risks, including:

- ***Baseline mischaracterization.*** Savings estimates are generally developed from engineering formulae that incorporate a variety of factors like annual hours of operation for the facility, patterns of occupancy, and temperature. If these assumptions do not reflect actual conditions at the site, or if conditions change over the course of the measure's life, then the estimated energy savings will differ from actual energy savings.

- ***Weather effects.*** Savings in space heating and cooling represent over 40% of total potential savings, assuming normal weather conditions; however, if weather conditions are substantially milder than normal, as in 2006, energy savings will be lower. Conversely, these may be higher if temperature variations are more extreme than normal.
- ***Problems in design or installation of efficiency measures.*** Such defects prevent proper functioning and reduce savings.
- ***Problems in operation and maintenance.*** Similarly, if equipment is not operated and maintained per manufacturer or vendor specifications, the energy savings delivered will not meet expectations.

In order to mitigate these risks, utilities and other institutions have developed cost-effective approaches to assess savings delivered through installed measures. These approaches are defined in the *International Performance Measurement and Verification Protocol* and the *California Evaluation Protocols.*[30] The typical series of steps in the recommended approach are as follows:

- Developing a database for all energy efficiency projects conducted, characterized by building type, measure types, quantity of measures installed, date of installation, various baseline conditions, and expected level of energy savings;
- Periodically drawing a random sample of projects, segmented by measure type and size, for measurement and verification;
- Conducting on-site inspections of the sample measures to ensure that installation occurred as reported;
- Comparing verified and estimated savings at the site level and identifying causes for potential differences; and
- Expanding the results of the sample to the population using statistical analysis.

Next Steps. The Steering Committee will develop and manage the deployment of performance measurement and verification activities to assess the success of its efforts to reduce energy consumption and GHG emissions. Information gained from these activities will be used to direct energy efficiency project selection and management efforts in subsequent years. The Steering Committee will use the *International Performance Measurement and Verification Protocol* and the *California Evaluation Protocols* as guides to develop its approach.

[30] *International Performance Measurement and Verification Protocol.* Revised March 2002. Oak Ridge, TN., U. S. Department of Energy, Office of Science and Technical Information.
The TecMarket Works Team. *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.* San Francisco: State of California Public Utilities Commission.

4.3.5 Professional Support for the Plan

In order to best plan, manage, and coordinate the recommended initiatives, the Steering Committee will need to further expand its professional staff by building on existing programs and expertise within City agencies, and by leveraging external resources to the maximum extent possible. Outside entities, including quasi-public authorities, private corporations, and non-profit organizations can offer distinct advantages over City agencies in addressing the various challenges the City will face in implementing the initiatives recommended under this Plan.

Figure 13 reflects the Steering Committee's evaluation of the advantages and disadvantages of each entity type.[31]

Figure 13: Relative Strengths of Organizational Forms

	City Agency	Quasi-Public Authority	Private Corporation	Non-Profit Organization
Access to appropriations	○	○	---	---
Flexibility in use of public funding	◉	○	---	---
Flexibility in construction contracting	---	○	◉	◉
Costs of construction	---	○	○	○
Flexibility in contracting for services	○	○	◉	◉
Cost of capital	◉	○	---	---
Flexibility in hiring & rewarding personnel	---	○	◉	◉
Access to data and ease of coordination w/ city agencies	◉	○	---	---
Ability to attract private equity investment	---	---	◉	---

◉ = Relative strength
○ = No distinct advantage or disadvantage
--- = Relative weakness

Next Steps. The Steering Committee will develop a more detailed plan over the coming months to expand its ability to provide centralized support and coordination for the Plan, as needed.

4.3.6 PlaNYC Sustainability Advisory Board

The City's Sustainability Advisory Board, created in September 2006 to inform the creation of PlaNYC, continues to serve an important role in the implementation of PlaNYC initiatives. The Board consists of representatives from the design and development community, national environmental and local environmental justice groups as well as business, labor, and construction. The Board helps keep the City accountable

[31] The Steering Committee has not conducted formal research on the powers and chartering requirements for quasi-public authorities, private corporations, or non-profit organizations in New York State.

for meeting the milestones set in PlaNYC, and its members continue to provide input and offer technical expertise on the implementation of initiatives through topic-specific working group meetings. Members also share information on emerging technologies and practices with the City. The Sustainability Advisory Board will be an important asset to the Steering Committee as we move forward with the implementation of the Plan.

4.3.7 Project and Program Funding Sources

The City's commitment to allocate an amount equivalent to 10% of the annual energy budget for this initiative amounted to $80 million in FY'08 and will total $100 million for FY'09.[32] Over the next nine years, this is estimated to total over $900 million. While the City will pay for an additional portion of the overall investment through the agency appropriations process (e.g., routine maintenance and renovation projects which also often include GHG reduction savings), the City will still face a significant funding gap when compared to the estimated $2.3 billion in FY'08 dollars required to achieve its GHG reduction goal by 2017. In other words, annual investments must average roughly $280 million between FY'10 and FY'17.

Next Steps. In order to achieve the City's GHG reduction goal, the Steering Committee will explore the following potential sources of funding for various aspects of the Plan, in addition to the City's internal funding mechanisms:

- ***New York State matching funds.*** The Department of Education and CUNY are eligible for matching funds from the State of New York for capital improvements to school and university buildings which can fund up to 50% of project costs, and support large-scale capital improvements including energy projects.
- ***Dormitory Authority of the State of New York (DASNY) funding.*** DASNY is a public-purpose organization with revenue bonding authority. CUNY and the Health and Hospital Corporation can finance capital improvements for select types of facilities at favorable rates through DASNY.
- ***ENCORE program.*** NYPA's ENCORE program provides project financing to participating municipalities at relatively favorable rates. In recent years, the City has elected to self-finance ENCORE projects directly to take advantage of its own favorable borrowing rates.
- ***Energy performance contracting.*** Energy service companies (ESCOs) arrange project financing as part of a package of services designed to expedite project development by large commercial and industrial customers. Where a municipality is the customer, project financing is generally arranged through a municipal lease. From a purely financial standpoint, such an arrangement is much like any other form of borrowing; however, ESCOs also offer a variety of pricing mechanisms that mitigate completion and performance risks to the customer. These include pricing the transaction as a share of verified savings over time or providing a guarantee for a negotiated level of savings. These transactions are

[32] An increase of $20 million due to an increase in energy costs for the City in FY'07 versus the prior year.

generally structured so that the customer bears the cost of the risk mitigation strategies.

- ***Expanded participation in demand response programs.*** The New York Independent System Operator (NYISO) operates a number of demand response programs through which owners of large facilities may receive payments in return for reducing their electric demand during periods of very high demand. The NYISO offers the following two programs:
  - The Emergency Demand Response Program is designed to reduce power usage through the voluntary shutting down of businesses and large power users. The companies are paid by the NYISO for reducing energy consumption when asked to do so by the NYISO. The amount of the payment is based on the reduction of demand below a calculated baseline amount.
  - The NYISO's Day-Ahead Demand Response Program (DADRP) allows energy users to bid their load reductions, or "negawatts" into the Day-Ahead energy market as generators do. Offers determined to be economic are paid at the market clearing price. DADRP allows flexible loads to effectively increase the amount of supply in the market and moderate prices.
- ***Private foundations.*** Recently, a number of private foundations, including most prominently the William J. Clinton Foundation's Clinton Climate Initiative (CCI), have supported efforts by cities to reduce GHG emissions. CCI's first major program, the Energy Efficiency Building Retrofit Program, brings together many of the largest energy service companies, financial institutions, and cities in an effort to reduce energy consumption in existing buildings. CCI is working to leverage the buying potential of cities throughout the world to achieve favorable pricing on energy-efficient and clean energy products and technologies.
- ***Matching funds for vehicle improvements.*** The Steering Committee has identified a number of potential sources of funds for program activities to reduce emissions from vehicle fleets. The New York State Energy Research and Development Authority periodically awards competitive grants to support technical studies and pilot projects in this area, as does the New York Power Authority. The Congestion Mitigation and Air Quality (CMAQ) program operated by the U.S. Department of Transportation has provided funds to the City DOT for projects to reduce air pollution. These funds must be used during the period 2005 – 2010. DOT distributes these funds to other City agencies on a competitive basis, which may be used for the following purposes:[33]
  - 80% of the incremental cost of an alternative fuel or advanced technology device;
  - Hybrid trucks, electric vehicles, natural gas vehicles;
  - Diesel retrofit equipment; and

[33] CMAQ does not cover biodiesel fuels, unplated vehicles, high mileage conventional equipment, or hybrid sedans, except under special circumstances.

- Certain educational materials.

4.4 Program Implementation Schedule

Figure 14 consolidates the recommended implementation activities from the sections above and provides a rough timetable of next steps for each.

Figure 14: Program Implementation Schedule

July 2008 – December 2008	January 2009 – June 2009
Capital Projects	
<u>General</u> – Develop standardized and customized project application processes – Select FY'09 projects and begin implementation – Identify additional procurement methods	– Continue implementation of FY'09 projects – Evaluate project management needs at agencies – Begin procurement for new contract opportunities
<u>Replacements and Retrofits</u> – Develop guidance documents for project development – Develop list of typical recommended projects – Identify additional sites for full-building audit program – Complete small-scale renovations study	– Work with agencies to systematically identify project opportunities in facilities
<u>Street Lighting</u> – Continue upgrade plan	– Monitor new opportunities
<u>Clean Distributed Generation</u> – Identify FY'09 candidate sites for cogeneration projects and complete initial feasibility assessments – Select vendor for solar PV purchased power agreement	– Select sites for cogeneration project development – Negotiate solar PV purchased power agreement
<u>Wastewater Treatment Plants</u> – Assist DEP with planning and engineering for high-priority projects	– Assist DEP with development of overall energy management plan
<u>Vehicles</u> – Complete fleet efficiency study on new technology and recommendations on O&M improvements	– Begin implementation of recommendations
<u>New Construction</u> – Work with agencies not covered by LL86 to broaden participation in design review and database	– Assess expansion of LL86 and standardization of renovations across programs

July 2008 – December 2008	January 2009 – June 2009
Emerging Technologies – Identify pilot projects	– Implement pilot projects and continue evaluation of new technologies
Operations and Maintenance	
Retrocommissioning – Assess results of retrocommissioning pilot – Assess value of LEED-EB portfolio approach Improved Practices – Complete interviews and research – Develop recommendations for Citywide initiatives	– Expand stand-alone retrocommissioning of facilities, as appropriate – Develop action plan for key recommendations, such as protocols, standards, and training curriculum – Initiate roll-out of Citywide effort
Coordination and Support for Agency Activities	
– Review support activities with participating agencies (such as information sharing, seminars, training)	– Add additional ELOs in selected agencies – Continue development of additional support activities
Building Performance Tracking and Information Management	
– Award contract for development of the building performance database	– Manage development and testing of the building performance database
Application of Advanced Metering and Monitoring Technology	
– Award RFP contract for research on business case and pilot program designs	– Develop solicitations for pilot programs to assess costs and benefits of selected metering and BMS systems
Performance Measurement and Verification	
– Develop measurement and verification plan – Specify sampling and site verification methods	– Conduct and assess initial round of site savings verification
Professional Support for the Plan	
– Develop recommendation on expanding centralized and technical support for the Plan	– Implement recommended changes and additions
Project Funding	
– Allocate FY‘09 project funding and process approval – Identify additional program funding for increased spending above current allocation	– Continue to track program expenses and verify savings through measurement and verification

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