Climate: *Change*

The City of Boston's Climate Action Plan

December 2007

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Introduction

On April 13, 2007, Mayor Thomas Menino issued an executive order "relative to climate action in Boston." This order, the latest in a series of actions that has made the City of Boston a leader in responding to the dangers of global climate change, established the goal for Boston of reducing emissions of greenhouse gases by 80 percent by 2050 and set broad policy guidelines for reaching that goal, both in municipal operations and in the entire Boston community.

The City of Boston started down this path in 2000, when Mayor Menino, recognizing that "carbon dioxide and other greenhouse gases (GHG) released into the atmosphere will have a profound effect on the Earth's climate" and that "the City of Boston can take important steps to reduce greenhouse gas emissions and increase energy efficiency," enlisted the City of Boston in the Cities for Climate Protection Campaign of ICLEI—Local Governments for Sustainability. The City pledged to:

- Take a leadership role in increasing energy efficiency and reducing greenhouse gas emissions from municipal operations;
- Develop and implement a local action plan…to reduce both greenhouse gas and air pollution emissions.

In 2005, Mayor Menino joined other members of the U.S. Conference of Mayors in unanimously adopting the U.S. Mayors Climate Protection Agreement. The mayors agreed that their cities would "strive to meet or exceed Kyoto Protocol targets," which would require the U.S. to reduce GHG emissions seven percent below 1990 levels by 2012, and which now serves as a stepping stone toward Boston's more ambitious goal.

This document, the City of Boston's Climate Action Plan, is another step in the City of Boston's fulfillment of its commitments. The first section briefly reviews the link between greenhouse gases and climate change. The second section summarizes the sources of Boston's GHG emissions. The third section describes actions that the City of Boston is taking to reduce its own energy use and waste and, therefore, GHG emissions. In many instances, City programs encourage or require residents, businesses, and institutions to adhere to GHG-reducing policies. The last section presents the Mayor's executive order, which provides the framework for the City to advance climate action beyond the measures already underway.

Greenhouse Gas Science

The greenhouse effect is essential to life as we know it. Without it, the Earth would be icy and inhospitable. However, greenhouse gases (GHGs) in the Earth's atmosphere absorb some of the infrared energy radiating from the sunlight-warmed

surface of the Earth and raise the average temperature. Human activity is changing the concentration of GHGs in the atmosphere and altering the energy balance.

The gases of greatest concern are carbon dioxide, methane, nitrous oxide, and halocarbons. Carbon dioxide, produced primarily through the burning of fossil fuels, accounts for about 84 percent of all U.S. greenhouse gas emissions. Emissions of methane—from, for example, decomposing landfill waste, manure, and fermentation from livestock—account for another 7 percent. Nitrous oxide, seven percent of U.S. emissions, arises from agricultural soil management and combustion engines. Halocarbons are chemicals typically produced and used during industrial processes. Changing patterns of land use and land cover also alter the atmospheric balance, because soil, forests, and other vegetation have the potential to remove carbon dioxide from the atmosphere.

[GHG emissions are measured in units of equivalent CO2 (eCO2). To calculate the amount of eCO2, emissions of GHGs that are not CO2 are converted into the amount of CO2 with the same effect on global warming. For example, 1 ton methane = 21 tons eCO2.]

In 1988, the United Nations Environment Programme and the World Meteorological Organization convened the Intergovernmental Panel on Climate Change (IPCC) to produce authoritative, consensus evaluations of global climate change. The IPCC Fourth Assessment report *Climate Change 2007: The Physical Science Basis*, released in February 2007, concluded that:

> Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.
> …
> Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations. …Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns.

These changes to the climate will have widespread and various effects, including those on:

- **Human health**. Although warmer temperatures might decrease cold-related illnesses, summer heat waves, urban air pollution, extreme weather incidents, and drinking water shortages would produce a net increase in disease and mortality. Changing regional disease patterns could include increased incidence and severity of asthma and cardiovascular illness, and the spread of insect-borne diseases, such as West Nile virus and Eastern equine encephalitis (EEE), due to longer mosquito-breeding seasons.
- **Coastal systems**. A rise in sea level of one to two feet by the year 2100—in line with IPCC's most recent projections—would cause severe disruption for

residents in coastal areas and for biologically diverse and productive coastal ecosystems. Many low-lying and island countries face potentially catastrophic storm surges and tidal flooding. A sea-level rise of this size would cause the permanent flooding of less than 230 acres of land in Boston, less than one percent of its current area, but also lead to more frequent flooding of low-lying areas from storm surges.

- **Water resources**. Changes in the location, time of year, and form in which precipitation falls can alter the reliability and quality of water supplies, cause droughts or flooding, and threaten wildlife, water-dependent industries and transportation systems, and hydroelectric power production.
- **Ecosystems**. Climate change may affect the range of individual ecological systems, the mix of species within ecosystems, and the ability of ecosystems to provide the vast range of services that benefit human societies.
- **Agricultural production**. Changes in temperature, precipitation, and soil moisture will affect the distribution and productivity of crops and increase the prevalence of agricultural disease and pests.
- **Economy**. In New England, changes to the fall foliage season and the winter skiing season—reducing their length or altering their timing—could affect the tourism economy.

In its 2006 report *Climate Change in the U.S. Northeast*, the Union of Concerned Scientists estimated that, by mid-century, summer in Massachusetts will be similar to the summers now experienced by the region between Maryland and New Jersey.

Municipal GHG Emissions

The first step in controlling GHG emissions is to determine their sources. In 1990, the community of Boston—residents, businesses, institutions, and government—accounted for emissions of about 7 million tons of eCO2, about 14 tons per person (see figures 1a and 1b), roughly the same as the Massachusetts average and much less than the U.S. average (about 24 tons per person).

In the year 2000, municipal operations of the City of Boston—including schools, police and fire departments, libraries, and semi-autonomous agencies such as the Boston Housing Authority, the Boston Public Health Commission, and the Boston Water and Sewer Commission—accounted for emissions of approximately 300,000 tons of eCO2, based on an inventory compiled by the City. This is roughly five percent of the community total.

Municipal emissions are divided among four sectors: buildings, vehicles, streetlights, and water/sewage (see figure 2). Buildings, with their requirements for heating, cooling, and electricity, account for three-quarters of municipal energy consumption and GHG emissions. Most of the building-related GHGs come from heating requirements: by energy type, almost half the GHGs come from natural gas and fuel oil combined, which are used primarily for heating (see figure 3). Electricity—for buildings,

for streetlights, and for pumps in the water and sewer system—accounts for another two-fifths. In Massachusetts as a whole, about 88 percent of electricity generation is from fossil fuels.

By department and agency, the largest GHG emitter is the Boston Housing Authority (BHA), which accounts for about a third of municipal GHG emissions (see figure 4). The BHA, a quasi-independent municipal agency, is the largest landlord in Boston, with about 13,500 rental units providing housing for about 26,000 people; these GHG emissions reflect the necessities of heat, cooling, electricity, and hot water. The second largest GHG emitter is the Boston Public Schools (BPS), which accounts for about a quarter of municipal emissions. Most of BPS's emissions come from heating and providing electricity for schools; and the rest from school bus transportation. The third largest contributor is the Department of Public Works, and most of these emissions are from electricity and some natural gas for street lights.

Reducing GHG Emissions

Under Mayor Menino's leadership, the City of Boston has implemented many strategies that reduce GHG emissions and air pollution, and, in many cases, save taxpayer dollars. This section discusses actions that the City is taking to reduce energy use and to encourage practices that reduce GHG emissions. These include actions that the City is taking directly to reduce its own GHG emissions, actions that demonstrate to residents and institutions the feasibility and desirability of doing so, and structural changes that encourage or require others to adopt sustainable practices.

Actions are divided into five categories:

- Buildings and other structures
- Energy sources
- Transportation
- Waste management
- Land use and other actions

The government of the City of Boston is by no means alone in its concern about climate change and its efforts to reduce GHG emissions. Many residents of Boston are choosing to put extra insulation in their homes or to walk rather than drive, and many local businesses and institutions are making notable efforts to reduce energy consumption and introduce products and practices with lower GHG emissions. In April 2007, Mayor Menino gave the City's first Green Awards to twelve business and five residents who had gone above and beyond in their attempts to use green technologies and sustainable practices in their businesses and communities. To further focus the many efforts underway in Boston, the City is going to establish a Community Climate Action Task Force to set goals for community-wide GHG reductions and make recommendations concerning actions to meet these goals.

Buildings and other structures

About 78 percent of Boston's greenhouse gas emissions are related to buildings, their heating and cooling and electricity. The City of Boston is undertaking a variety of actions to encourage all sectors of the community to use energy more efficiently in their facilities and to create environments that are more energy-efficient.

Integrated Energy Management Plan for municipal buildings

In 2001, Mayor Menino appointed an Energy Advisory Committee and set the goal for the City of Boston of reducing its energy consumption by ten percent. In 2005, the Mayor's Energy Management Board—the successor to the Energy Advisory Committee—completed an Integrated Energy Management Plan (IEMP), which studied energy use in 362 municipal buildings and identified potential savings, particularly in the "Top Ten." Increasing the efficiency of those ten buildings alone could reduce municipal GHG emissions by about one percent as well as save money and lower the emissions of other air pollutants.

The plan's implementation steps, over which the Board, chaired by the Chief of Environmental and Energy Services, exercises continuing authority, include:

- Implement the recommendations of the energy audits of the Boston Public Library and City Hall, the two largest consumers among municipal facilities.
- Investigate, in detail, the possibility of cogeneration or photovoltaics in police headquarters, City Hall, fire headquarters, and other facilities.
- Update and streamline the administration of energy purchasing, and create a central database of financial, property, and utility information in order to analyze energy use. (Boston made its first bulk procurement of electricity for municipal operations in 2005. Creation of a central database is an ongoing project of the Energy Management Board.)
- Use energy efficiency standards developed for the IEMP.

Beyond these major recommendations, GHG reduction measures in buildings can consist of many small steps. For example, the Boston Public Health Commission retrofit their offices' lighting fixtures with energy efficient replacements. In January 2007, the Management and Information Systems Department installed, in the City Hall computer network, software that automatically turns off all computers at the end of the business day. MIS estimated that this measure would reduce electricity consumption by about 300 MWh per year, about two percent of the total electricity consumption in City Hall.

Boston Housing Authority

Since 1999, the Boston Housing Authority (BHA) has had an aggressive program to lower energy costs and increase energy efficiency at all of its properties. This program includes:

- Comprehensive planning. In 2001, BHA reviewed its developments to identify energy- and water-saving opportunities. Similar in approach to the City's

Integrated Energy Management Plan, which excluded BHA properties, the BHA's Energy and Water Efficiency Master Plan identified $9 million in annual savings that could be achieved by making energy improvements at 63 developments covering 14,300 apartments.

- Energy performance contracts (EPCs). From 1999 to 2001, the BHA signed two EPCs, which led to $17 million in capital improvements, and is in final negotiations on a third, which will lead to approximately another $40 million in improvements. EPCs are valuable tools, because they allow the cost of the capital improvements to be paid for out of the savings generated by energy and water conservation measures. Previous EPCs saw the installation of more efficient boilers and lighting and low-flow toilets. The next EPC will include, in addition to these, "cool roof" retrofits, photovoltaic systems, solar thermal installations, and combined heat and power systems.

- Green building. In conformance with Mayor Menino's green building directives, the BHA has adopted a "whole building" and environmentally conscious approach to its new projects. Specifically, it is incorporating LEED standards and Energy Star products into its projects, which may include combined heat and power units, photovoltaic installations, recycling of construction materials, and innovative ventilation measures. Some recent examples of this approach are: Maverick Landing, 413 public housing units in East Boston; Plant Court, a 45-unit redevelopment in Jamaica Plain; and a portion of the 2004–2005 West Broadway development in South Boston, which received the highest Energy Star rating possible at that time.

- Effective partners. BHA has worked closely with local utilities (Keyspan Energy, now part of National Grid, and NStar), government agencies and programs (Massachusetts Technology Collaborative and the U.S. Department of Energy's EnergyStar program), and energy service companies (Ameresco and Noresco).

The success of this program is illustrated by its effect on 9,300 federally funded BHA residential units (about two-thirds of all BHA units). From fiscal year 2003 to fiscal year 2005, total energy purchases dropped by about five percent and GHG emissions dropped by about eight percent. These benefits are in addition to the cost savings.

Boston Public Schools

The 139 schools and other buildings that are part of the Boston public school (BPS) system account for about 17 percent of the greenhouse gas emissions from municipal operations of the City of Boston. BPS currently enrolls about 58,000 students in kindergarten through grade 12 and employs about 9,000 teachers and other staff.

Creating an energy program

In 1984, the Boston Public Schools obtained a federal/state grant for a one-year contract with a consultant to conduct energy audits of and identify conservation measures

for 27 school buildings. When a few low-cost measures—particularly, a "lights out" education program and a boiler-cleaning program—produced substantial savings, BPS awarded the consultant a second one-year contract and, in 1986, established its own Energy Office. An initial estimate put potential energy savings at 20–25 percent, although, aside from the consultant's remarkable results, information about energy usage was meager.

The Energy Office developed an energy accounting and monitoring system to track monthly energy use and cost. The system calculates the annual energy index (AEI), measured in BTU per square foot, for every school building. The Energy Office uses the AEI to compare the performance of buildings and to identify trends. Monthly reports inform school headmasters and custodians about energy consumption and costs in their schools.

The Energy Office's regular audits of school buildings cover energy systems, operating procedures, maintenance routines, and energy consumption patterns, and identify conservation opportunities. With information from bills and audits, the Energy Office determines priorities for short-term and long-term projects and any need for personnel training and development. Low-cost/quick-payback projects include lighting improvements, control upgrades, and window treatments. Lighting had accounted for as much as 60 percent of BPS's annual electrical bill. By the late 1990s, over 80 percent of school buildings had significant lighting improvements, including: computerized lighting control systems for auditoriums, ball fields, and gyms; occupancy sensors for classrooms; replacement of older fluorescent lighting with newer lamps; replacement of mercury vapor lighting in gyms and pools with metal halide fixtures; and replacement of exterior incandescent lights with high-pressure sodium fixtures.

Longer-term projects typically start small. One important example is natural gas-fired combined heat-and-power (CHP) units (cogeneration units), which produce both heat and electricity. BPS installed its first CHP unit in 2000; in 2007, 31 CHP units in 21 schools produced annual savings of over $2 million in electricity costs on an $8 million investment. More recently, BPS has installed photovoltaic systems at three schools and is examining the possibilities of on-site wind power.

The Energy Office emphasizes education and training. Memos from the superintendent regularly remind school personnel of the importance of turning off lights and computers, of closing doors and windows during the heating season, and so on. The Energy Office has gathered information from building staff, the BPS engineering staff, and the energy audits to compile a database of building characteristics and operations to form the basis of training curricula for custodians.

Finally, the Energy Office has installed computerized energy management systems (EMS) throughout the school system. The EMS monitors environmental conditions (temperatures, status of lights, and so on), and automatically adjusts heating, ventilating, and air conditioning equipment, as well as some lighting and other equipment, ensures that energy-consuming devices are on only when they are needed,

and alerts the Energy Office of malfunctions (for example, a valve not working) so that maintenance personnel can be dispatched. The first-generation EMS monitored and controlled buildings by larger areas (for example, by floor or wing); the second generation, direct digital control, so far installed in four schools, monitors buildings at a more detailed level and can control nearly every valve and power switch.

Results

In the late 1980s, BPS facilities required, on average, close to 90 mBTUs per square foot per year (mBTU = 1000 BTUs) in combined purchases of electricity, natural gas, oil, and steam. By 1997, this had dropped to about 68 mBTUs per square foot (see figure 5a). This coincided with the closing of some old schools (which itself may have contributed to the rise in efficiency). Overall, annual GHG emissions dropped from over 80,000 tons eCO2 to less than 60,000 tons (see figure 5b).

Since the late 1990s, the average energy purchased per square foot has risen about 10–15 percent, in part due to the increasing number of computers and other electronic equipment in schools and BPS offices. In the same period, BPS opened several new schools, thereby increasing the overall area of BPS facilities by about 14 percent. As a result, total energy purchases have increased about 20 percent since the minimum. The increase in energy purchases is less than the increase in actual energy consumption, because on-site CHP and PV installations now generate—without additional GHG emissions—about 20,000 MWh of electricity annually, most consumed on-site, to supplement the 60,000 MWh of purchased electricity.

Total GHG emissions from BPS have increased about 10 percent since the minimum, less than the 20 percent increase in energy purchases, because heating oil, which used to supply about a quarter of BPS's energy needs, has been replaced by natural gas. Per BTU, natural gas produces about 25 percent less CO2 than fuel oil. This switch was driven by the CHP installations, which were designed to run on natural gas and replaced oil-burning boilers. Despite the recent increases, total energy purchases and total GHG emissions are both much less than they were in the late 1980s.

Green building standards

Since 1997, the Boston Environment Department has urged all developers subject to development and environmental review to adopt its High Performance Building Guidelines and Construction Guidelines. In 2002, moving to a higher level of commitment, the City constructed its first municipal green building, the George Robert White Environmental Conservation Center. Intended to serve as a regional model for environmentally responsible building principles, the White Center includes: siting and orientation to maximize the availability of natural daylight; renewable energy technologies such as geothermal heat pumps, photovoltaic shingles, and a solar hot water system; advanced insulation, high-performance glass, and sound construction techniques that create a tight building envelope; and wood from sustainably harvested forests, materials from local sources including Roxbury Puddingstone, and products with recycled content. It provides easy access by public transit and hospitality to cyclists, with

showers in an adjacent building and a convenient bicycle rack. A final report on the project concluded:

> The building was designed to use 30–35% less energy than a conventionally designed building of similar size. Since the building uses no gas for heating or appliances, the only energy utility Mass Audubon pays for is electricity. The building's engineers anticipated that the [White Center] would use 12.6 kWh per square foot annually, or a total of approximately 128,000 kWh, without factoring in electricity generated by the building's photovoltaic system. Based on the building's first year of electricity bills, it is using slightly less electricity than expected.

Concurrent with construction of the White Center, Mayor Menino appointed a Green Building Task Force to produce a "comprehensive examination of every facet of green building." The next year, the task force outlined "Next steps for Boston—A 10-Point Action Plan." As a result, the City adopted the LEED (Leadership in Energy and Environmental Design Green Building Rating System) Silver standard of the U.S. Green Building Council as its guideline for renovation and construction of all City facilities, and is providing LEED training to planning, design, and review employees (more than 60 to date). The new Charlestown Police Station and the new Mattapan Branch Library are the initial projects to which the Property and Construction Management Department is applying this standard.

Extending similar requirements to private development, the Boston Zoning Commission, in January 2007, adopted a Green Buildings provision, the new Article 37, for Boston's zoning code. This requires that projects over 50,000 square feet be "LEED certifiable." In addition to the standard LEED points, the Boston provisions make available four additional points that reflect priorities of the City in regard to mobility (transportation), the electrical grid, historic preservation, and groundwater. In January 2007, to further spur developers toward green building, Mayor Menino filed, in the Massachusetts General Court, *An Act Establishing A Green Building Income Tax Credit* for developers, owners, and tenants of commercial and multi-family residential buildings.

Mayor Menino's 2007 executive order raised the standards for City projects a step higher by requiring that City facilities obtain formal LEED certification and that, in doing so, all new projects exceed the basic standard for energy performance by at least 14 percent and all major renovations exceed the basic standard by 7 percent. The new Dudley Square Police Station, planned to begin construction in 2009 will be the first LEED Silver project designed under that requirement.

Green affordable housing and neighborhood development

The City of Boston, working primarily through its Department of Neighborhood Development (DND), has moved quickly to extend green-building principles to its programs in affordable housing and neighborhood development and to expand the capacity of developers to integrate renewable energy, energy efficiency, green building, and healthy home practices early in the development process:

- As part of a requirement that all new construction and major renovation projects receiving City funding or land are "LEED certifiable," DND has incorporated green guidelines into its notices of funding availability.

- The City is developing a resource guide to provide technical assistance to developers and to introduce green building practices at the earliest possible stage of planning.

- DND is developing checklists on green building standards for homeowners and residential contractors and a program to recognize best practices and design innovation in residential construction and renovation. The initial focus is on buildings with one to three residential units.

The largest program in this effort—led by DND, in partnership with the Boston Housing Authority (BHA), the BRA, the Public Health Commission, and other City departments—is using a $2 million grant from the Massachusetts Technology Collaborative (MTC) to incorporate renewable energy, energy efficiency, green design, and healthy homes construction practices into the City's affordable housing program. Through outreach, training, and project management, and the coordination of resources of MTC, the Enterprise Foundation, NStar, and KeySpan, the program aims to make these practices commonplace. As concrete result, the program expects to install 130–160 kW of photovoltaic capacity on four to seven buildings with a total of about 200 housing units.

In conjunction with the MTC grant, the City also received $100,000 of foundation funding for consultative program management during 2007 to assist in integrating the funding and resources available for the creation of affordable housing in Boston. In addition, DND staff receive ongoing training by the Green Roundtable on the early-stage integration of design, engineering, construction, and building operations.

Following Boston's adoption of green building standards, a local foundation funded the establishment of the Green CDC Initiative (GCDCI) and formed the Green Building Production Network (GBPN), a collaboration of five financing, technical-assistance, research, and advocacy organizations. The GCDCI supports community development corporations in planning and implementing environmentally sound development. GBPN is providing two million dollars in grants, loans, and technical assistance to four projects that altogether create or preserve over 800 units of state-of-the-art green affordable housing in Boston and Cambridge. Although not a formal member of the Network, the City of Boston works closely with it to support green development.

Green roofs

In 2005, the City of Boston installed a demonstration green roof on the eighth- and ninth-floor balconies of City Hall. A comprehensive system of waterproofing, growing medium, and plants that replaces a conventional roof, a green roof reduces energy consumption for heating and cooling, the urban heat island effect, and storm water run-off. In May 2006, the City hosted the fourth annual International Greening Rooftops for Sustainable Communities Conference, Awards and Trade Show, a three-day

conference exploring policies for supporting green roofs, design and implementation issues, and research concerning green roofs' performance.

There are already at least 10 green roofs in Boston, including one on the renovated Children's Museum, and several more are planned, including those on the private conversion of the former South End police station and the renovation of the McCormack Federal Building.

Installation of LED traffic lights

As recommended in the IEMP, the Boston Transportation Department (BTD) is converting all City traffic signals to LEDs (light-emitting diodes), which use about 90 percent less energy than incandescent bulbs and save taxpayers about $400,000 annually. By March 2006, BTD replaced over 11,000 green and red lights and pedestrian crossing signals, and is currently at work changing the electrical modules and bulbs for 1,800 more pedestrian-crossing signals.

Energy Sources

Facilities cannot only become more energy-efficient; they can also obtain the energy that they need, particularly electricity, from sources with lower GHG emissions. The actions described in this section have the latter goal.

Renewable energy procurement

Since starting to make its own bulk purchases of electricity in March 2005, the City of Boston has specified that an increasing proportion of the power must come from renewable sources. The original 2005 contract required approximately seven percent renewables for the 200 million kWh under contract, which qualified the City for EPA's Green Power Leadership Club. In 2006, that percentage rose to about 8.6 percent. In 2007, the City purchased renewable energy credits equivalent to 11.7 percent of its electricity purchases. This carbon offset is equivalent to about two percent of the City's GHG emissions. The Mayor's executive order on climate action requires that, by 2012, at least 15 percent of electricity purchased by municipal departments shall come from renewable sources.

The Regional Greenhouse Gas Initiative, a voluntary inter-state compact that Governor Deval Patrick signed in January 2007, will start to limit GHG emissions from electrical generating units in Massachusetts and other states from Maine to Maryland in 2009. Because of City of Boston bulk purchasing, it is uncertain how this general measure will affect the City's GHG emissions.

Solar energy

The City of Boston installed its first photovoltaic (PV) system of 2.8 kW in the George Robert White Environmental Conservation Center at the Boston Nature Center, Mattapan. In addition to providing energy, the solar installation at this building is an educational tool, teaching visitors about solar power and its contribution to building operations and protecting the environment.

In 2004 and 2005, the Boston Public Schools, working with the Massachusetts Energy Consumers Alliance and MTC, installed a total of 6.6 kW of PV capacity at three schools: the O'Bryant School, the Boston Arts Academy, and the Murphy School.

In 2006, the City's efforts to increase the number of solar installations received a major boost, when its Department of Neighborhood Development received a $2 million grant from the Massachusetts Technology Collaborative; the grant will lead to 130–160 kW of installed capacity on four to seven buildings of affordable housing. (See Green affordable housing and neighborhood development.)

In June 2007, the City of Boston received a $150,000 grant from the federal Department of Energy plus technical assistance to establish Solar Boston, a program to maximize solar technology's role in sustainable development, educational, and emergency preparedness policies. Its objective is the installation of photovoltaics and solar thermal on all feasible and appropriate locations throughout Boston. The City will:

- Establish the Solar Boston Partnership to coordinate resources and best practices of the City of Boston, the Department of Energy, the Commonwealth of Massachusetts, utilities, electrical workers' union, solar industry, and non-governmental organizations;

- Examine barriers to solar's widespread deployment and establish the basis for the comprehensive installation of solar technology throughout Boston, including mapping feasible locations, marketing to sites, preparing a project-labor agreement, and planning the city-wide bulk purchase, financing, and installation of solar technology;

- Create a successor non-profit organization, Solar Boston, Inc., to implement the plans of the partnership.

Wind energy

In May 2005, the International Brotherhood of Electrical Workers, Local 103, setting an example for the entire city, completed installation of a 149-foot, 100-kW wind turbine at its Boston training facility in Dorchester, Massachusetts, next to the Southeast Expressway, where 100,000 vehicles travel daily. Local 103 uses the turbine, along with a photovoltaic array also on site, to train its members to install renewable energy technologies.

The City of Boston is promoting pilot projects to examine the potential for wind power in Boston. The City of Boston is working with the Community Wind Collaborative of the Massachusetts Technology Collaborative (MTC) to study the feasibility of installing wind turbines on Long Island in Boston Harbor. This study builds upon the MTC-funded *Boston Harbor Islands Renewables Planning Guide*, prepared by the University of Massachusetts Boston, Urban Harbors Institute, which analyzed the resources of the grid-tied Boston Harbor Islands, identified alternative technologies and

sites, and assessed environmental, community and regulatory issues. The City is coordinating this project with another wind turbine project in Boston Harbor proposed by the Massachusetts Water Resources Authority. Both Boston projects are working with the Commonwealth and the MTC to address concerns raised by the Federal Aviation Administration regarding the proximity of wind turbines to Logan Airport.

Distributed generation

Photovoltaic systems and wind turbines are two examples of energy sources that can be used for distributed generation (DG), the on-site generation of electricity. Other examples are natural gas-fired turbines, fuel cells, and combined heat and power (CHP) systems. Distributed generation reduces GHG emissions by, among other things, reducing transmission losses, increasing the efficiency of the entire electrical network, and providing an alternative to traditional infrastructure upgrades. As described earlier, the Boston Public Schools have already installed 31 CHP units. The City of Boston is actively encouraging the development of DG and urging the Massachusetts Technology Collaborative (MTC) to select a location in Boston for one of its Utility Congestion Relief Pilot Projects.

The City is working on many of the legal, financial, and engineering issues affecting the viability of DG projects. One major concern is the price that utilities charge customers with DG systems who wish to connect to the electrical grid to supplement a system that does not fulfill all on-site energy requirements or to provide a backup when the DG system breaks down or requires maintenance. In 2005, Mayor Menino filed *An Act Relative to Distributed Generation* in the Massachusetts General Court to require the consideration of "…improved environmental performance, avoided electricity transmission costs, reduced energy costs through combined heat and power generation, decreased exposure to electricity price volatility, increased efficiency and improved power quality and reliability…" in negotiations regarding stand-by charges for facilities with DG, but this bill was not passed by the legislature. The Mayor's Office has also joined the DG Collaborative, a forum hosted by the MTC and recognized by DTE to develop an interconnection tariff and to examine the role of DG in electricity distribution system planning.

Transportation

Transportation accounts for about 18 percent of Boston's greenhouse gas emissions. Most of this is from automobile traffic. The City recently conducted a review of all the modes of transportation by which people move in and around the city. *Access Boston 2000–2010* established a long-range plan for reducing VMTs (vehicle miles traveled) in the Boston area—for example, by promoting trip reduction and the use of mass transit—and improving the flow of traffic that remains. Also, the City of Boston encourages the use of alternative-fuel and low-emission vehicles of all sorts, for example, through the outreach activities of the Public Health Commission's Environmental Hazards Program. This reduces GHG emissions and emissions of other air pollutants, and improves the overall quality of life for residents and visitors.

City of Boston fleet policy and promotion of alternative-fuel vehicles

In model year 2001, the Boston Public Health Commission purchased its first hybrid vehicles, and now has 13 hybrid vehicles—including a police vehicle and emergency response SUV—in its fleet of 59 vehicles. In September 2005, Mayor Menino announced that all new vehicles purchased by the City of Boston will be alternative fuel vehicles or the most fuel-efficient vehicles available, a directive reinforced in the recent executive order.

In February 2006, 450 City diesel vehicles, including light-duty trucks, snowplows, ambulances, and fire trucks, began using a five-percent biodiesel blend (B5). The Mayor's executive order now requires the use of B5 in all municipal diesel vehicles. Based on fuel consumption in fiscal year 2000, this will lower the City's GHG emissions about one-third of one percent.

Beyond its own procurement, the City of Boston actively promotes the wider use of alternative-fuel vehicles. Mayor Menino supports the National Plug-In Partner Campaign, a national effort to encourage manufacturers to produce flexible-fuel plug-in hybrid vehicles, and the City has placed a "soft" order—that is, indicated its willingness to seriously consider an order—for 200 plug-in vehicles. In 2007, the City of Boston hosted the fifth annual AltWheels sustainable transportation and energy festival on City Hall Plaza. The festival exhibited hydrogen fuel cell, electric, solar, ethanol, and hybrid vehicles, as well as other forms of sustainable transportation, and included forums to discuss the issues—practical, economic, and political—surrounding their use. AltWheels will return to Boston City Hall Plaza in September 2008.

Completion of the Big Dig and expansion of the mass transit network

The Central Artery/Tunnel (CA/T) project, designed to improve the overall highway system through Boston, is essentially complete. Associated with the project are many agreements and commitments—by and among federal, state, regional, and city agencies—designed to ensure that other transportation modes expand equally, so that completion of the project improves overall air quality and does not just bring more cars more quickly into the city. The City works closely with the Massachusetts Bay Transportation Authority (MBTA), the Boston Metropolitan Area Planning Council, and others to shape regional transportation priorities and to ensure implementation. Mass transit projects recently or soon to be completed include opening of phase II of the Silver Line, modernization of the Blue Line, renovation of the Fairmount Line, and the purchase of new, lower-emission diesel buses.

Transportation access plan agreements and transportation demand management

The Boston Transportation Department negotiates TAPAs (Transportation Access Plan Agreements) for large projects. A central component of these agreements is transportation demand management (TDM) measures to reduce the dependence of residents, employees, and visitors on their automobiles and encourage trip reduction and the use of mass transit, and to establish construction management plans that minimize the amount of traffic and disruption from construction activities. The new green building

requirements adopted by the Boston Zoning Commission allow projects to obtain a green building credit for TDM measures.

Parking: freezes, stickers, rates

The City of Boston administers several complementary parking programs to discourage commuters—especially those in single-occupancy vehicles—from driving into the city:

- Parking freezes administered by the Air Pollution Control Commission in three areas of the city cap the total number of off-street parking spaces of various types (e.g., commercial, commuter).
- In many Boston neighborhoods, residents are eligible for parking stickers that allow them to park along curbs reserved for neighborhood use.
- The rates and maximum times at on-street parking meters and rates at some parking garages are set to deter peak-hour commuters.

Walking in Boston

The City of Boston is implementing a campaign to encourage more people—residents and visitors—to walk around the city. In 2006, the City sponsored "Sneakers on Statues," where people were invited to "[v]isit…famous statues and see what they've got on their feet," and announced completion of the Boston Harborwalk audio tour, which highlights 17 stops along 1.2 miles of Boston's spectacular harbor.

The City has also developed pedestrian safety guidelines to ensure that streets, intersections, and other parts of the city's infrastructure are designed with pedestrians in mind. The City is investing $24 million in City Walks, an aggressive three-year road and sidewalk repair project, and $450,000 in the Walk Safe initiative, launched by Mayor Menino in May 2006, to repaint crosswalks, especially at busy intersections, to provide safe pedestrian access in the city's neighborhoods.

Making bicycles more convenient

In September 2007, Mayor Menino launched Boston Bikes, a citywide initiative to make Boston a better biking city, and hired a new Bicycle Coordinator. Under this initiative, the City will install more bike racks, conduct a mapping project for planning bike routes, and undertake a count of the number of bicycle commuters and other riders in the city. In October, the City hosted the Boston Bikes Summit, an intensive three-day program with national experts, government officials, bicycle advocates, and local residents, to develop short-term recommendations for improving bicycling in Boston.

The City is expanding its network of bike trails, not just for recreational riders, but for those who want to bike to work and school. A $25,000 grant from the Boston Redevelopment Authority is funding the development of a master plan for the South Bay Harbor Trail—a 3.5-mile-long system from Ruggles MBTA Station to Fan Pier on the South Boston Waterfront—that Save the Harbor/Save the Bay is building.

The City already sponsors an annual Hub on Wheels festival to introduce residents to the extent of existing bicycle trails and other resources. To make bicycle use more convenient, developers of residential and commercial/industrial projects subject to Article 80 review are required, through the TAPA process, to provide secure bicycle facilities, which can include bicycle storage, bicycle racks, showers, and changing rooms.

Bicycles also have found a role in municipal operations. The Boston Police Department, Boston EMS, and the Boston Parks Department have all established bike patrols, which have proved popular.

Anti-idling activities

The City of Boston enforces the Commonwealth's law against the excessive idling of vehicles and conducts an extensive education campaign. The Transportation Department annually updates and distributes a pamphlet on Tour Bus Parking Guidelines, which emphasizes the prohibition against idling and directs tour buses to areas with lay-over parking. The Public Works Department installs dashboard decals on city-owned vehicles to remind drivers not to idle engines. A joint effort of several City departments has placed over 200 No Idling signs at city schools and provided training about the idling law to school bus drivers. The City of Boston also distributes its anti-idling dashboard decals and information brochures to the public.

Boston CleanAir Cabs

The Boston Police Department's Hackney Division recently established a demonstration program that allowed Boston's first hybrid taxicab (a Toyota Camry operated by Boston Cab Association) to go into service in August 2006, and as of December 2007, there were 30 on the road. Preliminary data from the first CleanAir cab showed fuel mileage of over 30 miles per gallon (compared to about 10 miles per gallon in the driver's previous cab), with a corresponding reduction in GHG emissions.

The CleanAir Cabs coalition—including City and state agencies and private individuals—is establishing incentives for more hybrid and alternative-fuel cabs, and actively informing drivers and companies of the opportunities. Massport allows CleanAir Cabs to bypass the normal taxi pool at Logan Airport and join the "short job" line twice per shift. The City awarded a Transportation and Air Quality grant to ICLEI—Local Governments for Sustainability to provide financial assistance of $1,000 to cab owners buying hybrids.

Retrofit of school bus fleet with pollution control equipment

Using $3.25 million from an EPA enforcement settlement with a local power plant, the City of Boston has retrofit nearly 600 school buses with pollution-control equipment and began supplying them with ultra-low-sulfur diesel fuel (ULSD) before the nationwide move to ULSD in October 2006. In the next two years, Boston Public Schools expects to purchase another 140 new buses to replace the older buses for which a retrofit was not possible. The project is reducing tailpipe emissions—primarily SO2, CO, and particulates—from the buses by more than 90 percent. There will be small reduction in CO2 emissions.

Boston Transportation and Air Quality grants

The City of Boston, with partial funding from the Commonwealth of Massachusetts, awarded its first set of Transportation and Air Quality grants in the spring of 2007 for demonstration, education, and research projects related to reducing air pollution emissions from on-road and off-road motor vehicles. The six winning projects, from neighborhood groups, non-profit organizations, and educational institutions, will encourage the use of mass transit and hybrid vehicles, work to make existing vehicles less polluting, and determine more precisely the relationship between local traffic and local air quality. The fiscal year 2008 grants will provide $50,000 in matching funds to Boston-based businesses that install emissions-reduction equipment on diesel vehicles.

Best Workplaces and TMAs

The U.S. Environmental Protection Agency and the U.S. Department of Transportation have recognized at least 50 individual Boston business, non-profit, and government organizations as "Best Workplaces for Commuters." In this voluntary program, organizations establish a variety of measures and incentives to reduce the number of employees driving to work in single-occupancy vehicles and to increase the use of mass transit and carpooling.

Individual organizations are also banding together to create transportation management associations (TMAs). Through these non-profit organizations, member businesses collaborate to promote traffic reduction and the increased use of mass transit, walking, and biking through shuttle-bus services, ride-sharing, subsidized transit passes, and other measures. There are now six TMAs in different neighborhoods of Boston, and the city strongly encourages their expansion. Membership in the local TMA is often a requirement of a new project's TAPA.

Waste Management

The collection and transportation of waste for landfill consumes energy. Decomposition of organic waste can produce the greenhouse gas methane. Overall, activities associated with collecting and disposing of waste account for a few percent of Boston's GHG emissions.

Increasing recycling

The City of Boston provides all Boston residents with recycling services, including weekly curbside pickup of paper, bottles, and cans, and seasonal or special pickups for other materials. In 2003, the City passed on ordinance requiring owners of large residential buildings to provide residents with access to this program. In FY 2007, Boston residents recycled over 17,000 tons of paper, bottles, and cans, 8,000 tons for yard waste, 500 tons of TVs and computer monitors, and 5,000 tons of large appliances, thereby reducing emissions by over 10,000 tons of eCO2. Recycling also has financial benefits for the City: every ton of recycling saves the city $70 of disposal fees.

As stated in the Mayor's executive order on climate action, the City intends to increase recycling of all materials by 10 percent by 2012. In the first four months of

2007, Boston public school students competed in a city-wide school recycling contest and recycled 400,000 pounds of paper, 200 times as much as the previous year. In May, the City moved seasonal yard waste pick-up from Saturdays to the usual neighborhood trash day to encourage more yard waste recycling and to make pick-up more efficient. Also in May, the City started a six-month pilot project for its "Recycle More" recycling method as a way to increase recycling tonnage. The City issued 65- and 95-gallon wheeled carts to 3,000 residents in some parts of Jamaica Plain and Roslindale to replace their current 14-gallon recycling bins, and asked them to put all recyclables in the carts without separating paper from plastic, metal, and glass containers, so-called "single-stream" collection. This pilot program has recently been extended to the South End.

To recycle surplus paint and used motor oil, the City operates collection centers in four neighborhoods from May through October. In 2005, Boston doubled the number of household hazardous waste drop-offs days from two to four.

Solar-powered trash containers

Boston has purchased 50 Big Belly Cordless Compaction units to be placed in selected high-trash, pedestrian-heavy locations. These solar-powered trash compactors crush trash and create more room for more debris, thereby reducing the frequency with which they must be emptied. The enclosed bins are expected to prevent trash from blowing away or being rifled through, discourage the dumping of household trash, and reduce personnel and fuel costs. Based on a six-month trial period, the City will determine how effective these barrels are.

Land Use and Other Actions

A critical factor in the long-term success of transportation actions is the success of land-use planning. For example, measures to reduce commuter traffic will not succeed, if new business and residential development is not coordinated with development of the transit system. The City supports the Commonwealth's efforts encourage transit-related development.

Although urban areas are characterized by density of development and intensity of use, parks, wetlands, and urban wilds are essential to quality of life. Furthermore, because plants consume carbon dioxide, the most prominent greenhouse gas, the protection of park land and undeveloped land is an important component of an urban climate action plan.

Tree planting and the urban forest

Boston, as a whole, has about half a million trees—about 40,000 of them "street trees"—providing a canopy that covers 30 percent of the City's land area. These trees sequester about 10,000 tons of CO2 per year, as well as remove other air pollutants, give shade, and improve public health and quality of life. The City of Boston, as a member of the Boston Urban Forest Coalition, a collaboration of non-profit, city, state, and federal organizations, participated in a complete survey of all the city's street trees of Boston,

completed in 2006, which is providing important information for management and maintenance activities. In 2006, the City planted about 476 new trees.

In April 2007, the Boston Urban Forest Coalition announced an ambitious program, "Grow Boston Greener," that aims to plant 100,000 additional trees on public and private properties in Boston, growing the City's canopy cover by 20 percent by 2020. This includes, in addition to the City's on-going efforts, a ten-year commitment from the Commonwealth of Massachusetts to spend $60,000 each year to annually plant 1,200 trees on state property in the city, and a five-year commitment to provide $20,000 a year for Arbor Day tree plantings throughout the city.

Also part of this program, the City of Boston is partnering with the U.S. Forest Service to develop the nation's first Urban Research Forest. The Forest Service currently maintains several research forests in national parks for studying the long-term ecological benefits of trees. The City is working with the U.S. Forest Service to develop a carbon offset program that will enable people to offset their carbon footprint by contributing to the growth and maintenance of Boston's urban forest.

Healthy Food and Fitness Initiatives

The City of Boston and the Boston Public Health Commission (BPHC) have an extensive campaign to reduce obesity among the city's residents by promoting healthy activities and eating. About half of Boston's residents are overweight or obese, with higher rates in the African American and Latino communities. The primary goal of the campaign is, of course, to reduce health risks from obesity, which include diabetes, cardiovascular disease, and high blood pressure. City programs and grants to neighborhood groups will teach children about nutrition, encourage restaurants to offer lighter, healthier menu options, provide more access to fresh, affordable produce, create more opportunities for exercise, and make our neighborhoods safer and more walkable.

These initiatives have secondary effects that reduce energy use and GHG emissions. For example, people who walk to their destinations are not burning fuel in cars; and food grown in urban farms or purchased at local farmers' markets may require less energy for its transportation and storage than that brought from distant farms.

A recent scientific paper estimated that, in the United States, every one-pound increase in average weight increases gasoline consumption—and, therefore, GHG emissions—by about 0.03 percent. The U.S. Centers for Disease Control estimate that the average American adult weighs about 25 pound more than 40 years ago.

Advancing Climate Action

In its 2007 Annual Energy Outlook, the U.S. Department of Energy projected that CO2 emissions from energy use in the U.S. will rise an average of 1.2 percent per year from 2005 to 2030, for a total 34 percent increase over that period. In comparison, the Kyoto Protocol—which the United States did not sign—asked developed countries to

reduce their GHG emissions below 1990 levels by 2012. Many groups, including ICLEI, are calling on developed nations to reduce their emissions by 30 percent below 1990 levels by 2020, 80 percent by 2050.

The City of Boston has accepted the 80-percent reduction goal by 2050 and the need to involve all segments of the community. Therefore, to advance climate action in Boston, Mayor Menino signed the following executive order on April 13, 2007:

EXECUTIVE ORDER
OF
MAYOR THOMAS M. MENINO

An Order Relative to Climate Action in Boston

Whereas, the City of Boston has been a leader in recognizing the threat of climate change by signing the U.S. Mayors Climate Protection Agreement and joining the ICLEI—Cities for Climate Protection campaign;

Whereas, the United Nations' Intergovernmental Panel on Climate Change has concluded that "Warming of the climate system is unequivocal" and that "Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations";

Whereas, climate change poses risks to Boston residents, visitors, businesses, institutions, and infrastructure, including risks associated with heat waves, changing disease patterns, sea-level rise, changing precipitation patterns, increased severity of storms and flooding, and stress on water and energy systems;

Whereas, the City of Boston has instituted measures to increase energy efficiency, ensure the use of green-building practices, increase the development and use of renewable energy, increase the fuel economy of the City fleet and the purchase of domestically produced biofuels, improve upon the size and health of the urban forest, as well as many other measures;

Whereas, additional actions that the City of Boston takes to reduce the threat of climate change will further improve energy efficiency, reduce the emission of air pollutants, create a cleaner and greener city, improve transportation and other infrastructure, expand business and educational opportunities, strengthen the economy, and save money; and

Whereas, the City of Boston has developed a Climate Action Plan, which describes the greenhouse gas emissions of municipal operations and actions that the City is taking to reduce such emissions;

NOW, **THEREFORE**, pursuant to the authority vested in me as chief executive officer of the City of Boston by St. 1948, c. 452, § 11, and every other power hereto enabling, I hereby order and direct as follows:

1. The City of Boston, consistent with its commitment under the U.S. Mayors Climate Protection Agreement, shall strive to meet or exceed the goal of reducing its annual greenhouse gas emissions seven percent below 1990 levels by 2012, and shall further reduce its annual greenhouse gas emissions by 80 percent below 1990 levels by 2050.

2. The City shall establish the Mayor's Community Climate Action Task Force. Upon appointment, the Mayor's Community Climate Action Task Force shall, within one year:
    a. Review the City's Climate Action Plan and make any appropriate recommendations;
    b. Complete a community-wide greenhouse gas emissions inventory and set goals for community-wide reductions;
    c. Make recommendations to the Mayor and the community concerning actions necessary to meet climate action goals and to take advantage of associated opportunities;
    d. Prepare educational materials for households and businesses in Boston describing global climate change and climate actions that they can take; and
    e. Identify economic and workforce development opportunities associated with climate action and the clean technology sector.

3. Every three years, the City shall update its Climate Action Plan, including recommendations for further actions to meet its energy and greenhouse gas reduction goals.

4. The City shall prepare an integrated plan that outlines actions to reduce the risks from the likely effects of climate change, and coordinates those actions with the City's plans for emergency response, homeland security, natural hazard mitigation, neighborhood planning and economic development.

5. Planning for all new municipal construction and major renovation of City-owned facilities and other major municipal projects shall include an estimate of annual energy use and greenhouse gas emissions. Such planning shall also include an evaluation of the risks posed by the likely effects of climate change through 2050 to the project itself and related infrastructure and a description of potential steps to avoid, minimize or mitigate those risks.

6. All existing municipal properties shall be evaluated for the feasibility of installing solar, wind, bio-energy, combined heat and power, and green roof installations. Projects with substantial reductions in greenhouse gas emissions

and a high return on investment shall receive priority consideration in the City's capital planning process.

7. All new construction and major renovation of City facilities shall obtain Leadership in Energy and Environmental Design (LEED) Green Building Rating System Silver level certification from the U.S. Green Building Council. As part of meeting the LEED standards, all new projects shall exceed the basic standard for energy performance by at least 14 percent and all major renovations shall exceed the basic standard by 7 percent.

8. The City of Boston, with the assistance of the Commonwealth of Massachusetts and the Kendall Foundation, shall work to develop the Boston Energy Alliance, a not-for-profit corporation, to implement a large-scale, cross-sector conservation initiative involving citywide energy efficiency, renewable energy, and demand-response implementation.

9. Electricity used by municipal departments shall include a minimum of 11 percent of power generated from renewable resources. By 2012, at least 15 percent of electricity purchased by municipal departments shall come from renewable sources.

10. All purchases of motor vehicles shall be alternative fuel, flexible fuel, or hybrid vehicles, unless they are not available for the needed function. New motor vehicles shall be the most fuel-efficient within their vehicle class. Diesel fuel used by municipal vehicles shall be at least five percent biodiesel. Total fuel consumption for municipal transportation purposes shall be reduced by a minimum of five percent by 2012.

11. The City shall increase recycling of all materials by 10 percent by 2012.

12. The City shall report annually on all energy consumption and greenhouse gas emissions, where applicable, through the Boston About Results performance measurement system.

13. The City of Boston Climate Action Initiative shall be implemented in conformity with any and all federal and state laws.

14. The provisions of this Order are severable, and if any provision, or portion thereof, should be held to be unconstitutional or otherwise invalid by any court of competent jurisdiction, such unconstitutionality or invalidity will not affect the remaining provisions, which will remain in full force and effect.

15. The provisions of this Order shall take immediate effect.

I further direct all Cabinet Officers, Department Heads, and City Employees to render such aid and assistance as is required for the implementation of the foregoing policy.

Thomas M. Menino
Mayor of Boston
April 13, 2007

Appendix

Notes on the Greenhouse Gas Inventory

To calculate greenhouse gas emissions and the effect of various actions to reduce those emissions, the City of Boston uses Clean Air and Climate Protection (CACP) software developed by ICLEI and the National Association of Clean Air Agencies (NACAA, formerly known as STAPPA/ALAPCO). For the municipal inventory, the City collects its own data on energy purchases by department and agency, in most cases, by fiscal year. For the community inventory, the City relies on annual production and distribution data supplied by local energy utilities, including KeySpan, NStar, Trigen, and by institutions—for example, some hospitals and universities—that produce power for internal use. The City's Department of Public Works supplies data on waste disposal and recycling.

The CACP software contains fuel-specific, region-specific, and, in some cases, technology-specific factors that convert energy and waste data into greenhouse gas emissions. The software is continually updated to reflect both temporal changes (for example, the fuel mix that produces electricity in a given region changes year by year) and changes in scientific understanding (for example, the factor for converting methane emissions into equivalent CO2). It also allows the City to create, where appropriate, Boston-specific factors.

There are many open technical and policy issues regarding GHG calculations. For example, when using region-specific data, how large should the region be? (The CACP software uses data from the Northeast Power Coordinating Council/New England for Boston.) What is the appropriate emission factor for corn-based ethanol? (The current CACP software uses zero, while some calculators make the ethanol factor very close to gasoline's.) Should a municipality count all the fuel used by airplane flights that originate in its airport? (Currently left to the discretion of the municipality; at this stage, the City of Boston does not.) The City of Boston participates in a local working group to discuss these issues with the Commonwealth of Massachusetts, other municipalities, and some large institutions; at a larger scale, ICLEI is working with other national and international organizations to develop widely acceptable protocols and standards. As this work proceeds, we may revise inventories to reflect changes in protocols and emission factors. See the City of Boston's climate Web pages for detailed GHG inventories and more extensive notes.

Figure 1a.

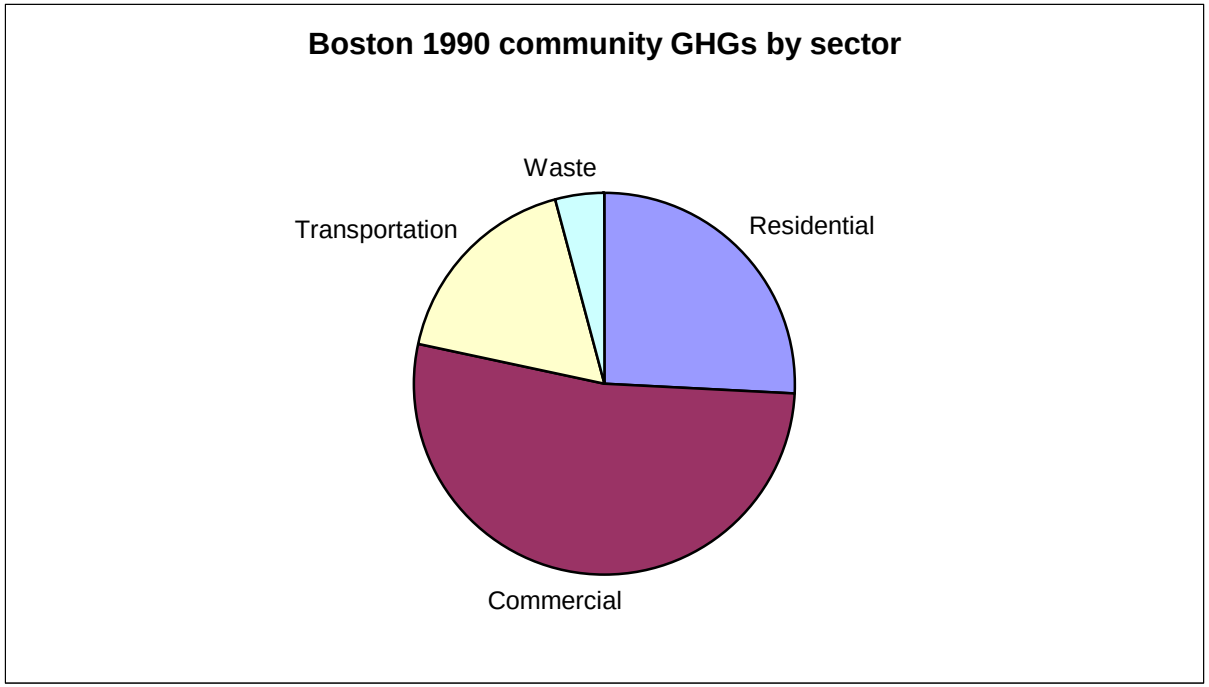

Boston 1990 community GHGs by sector
Waste
Transportation
Residential
Commercial

Figure 1b.

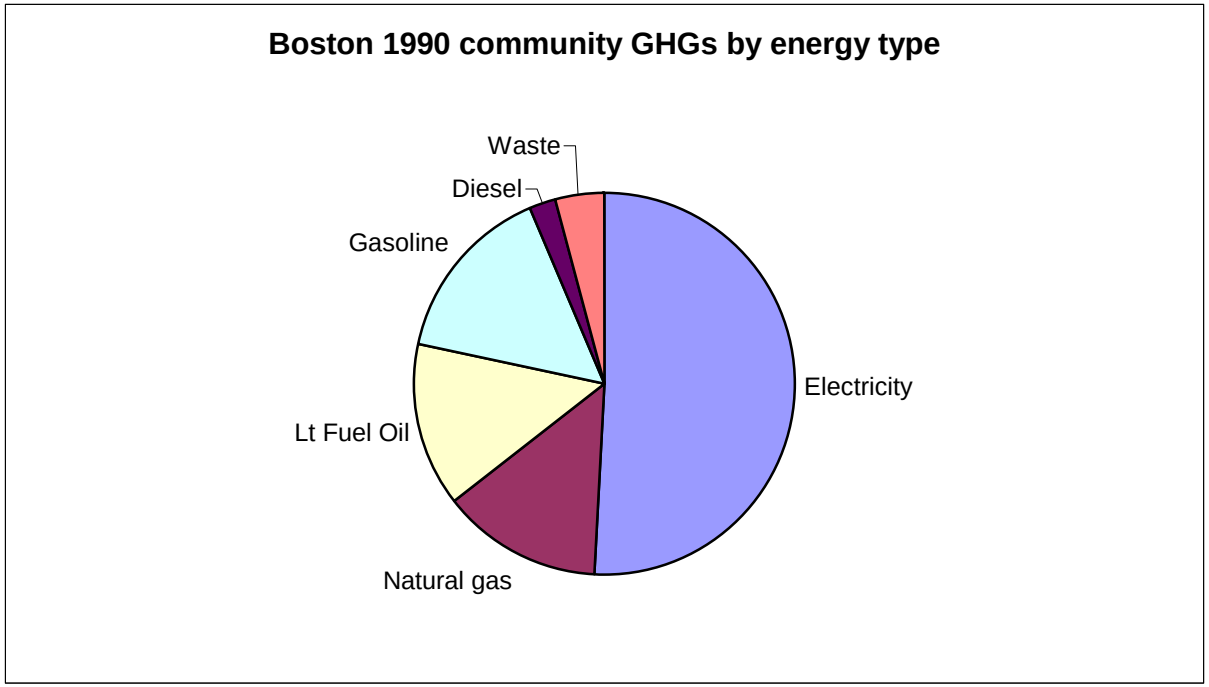

Boston 1990 community GHGs by energy type
Waste
Diesel
Gasoline
Electricity
Lt Fuel Oil
Natural gas

Figure 2.

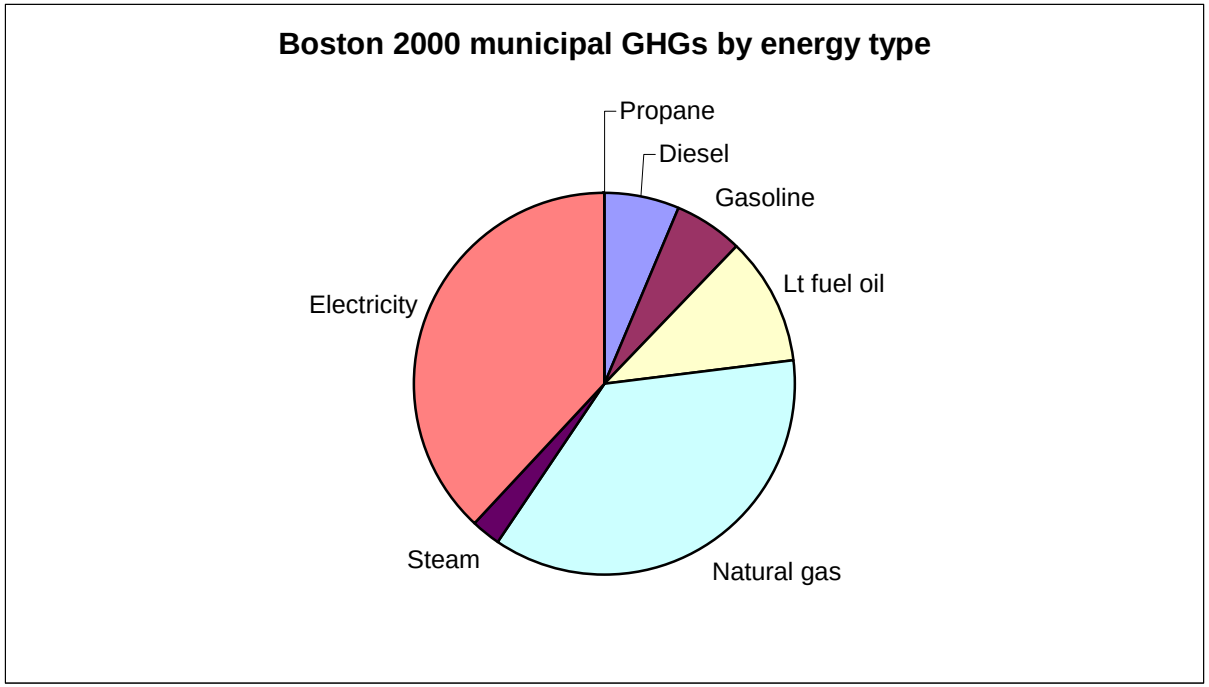

Boston 2000 municipal GHGs by energy type
Propane
Diesel
Gasoline
Lt fuel oil
Electricity
Steam
Natural gas

Figure 3.

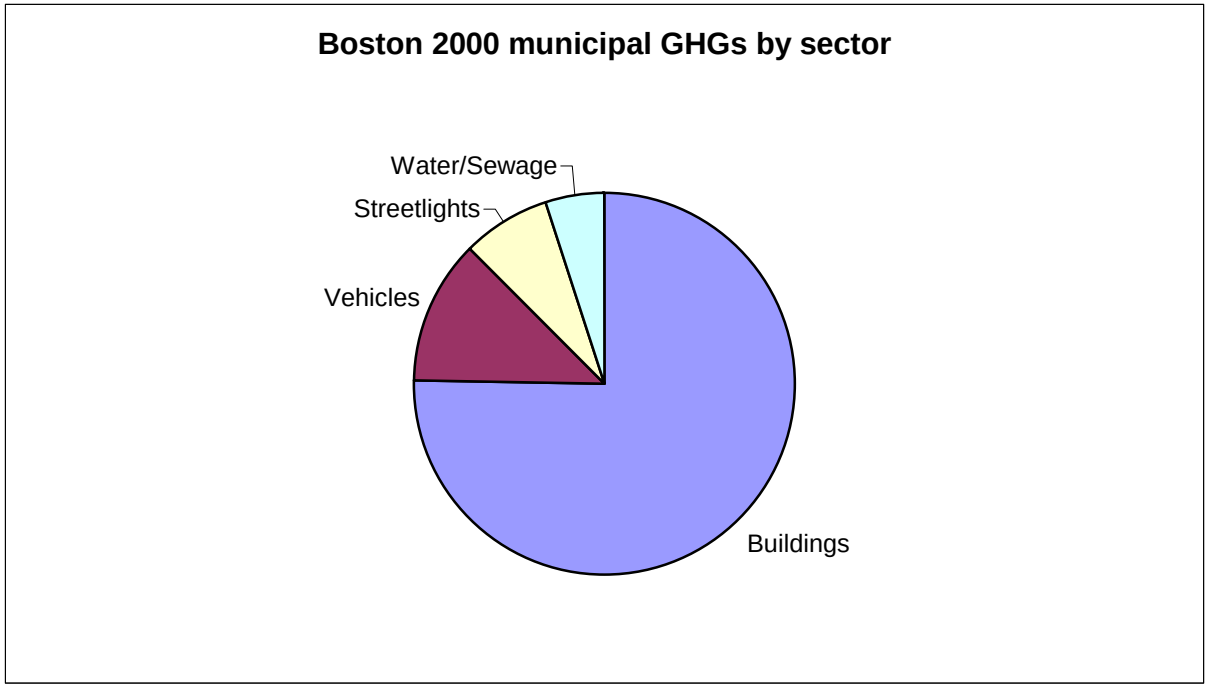

Boston 2000 municipal GHGs by sector
Water/Sewage
Streetlights
Vehicles
Buildings

Figure 4.

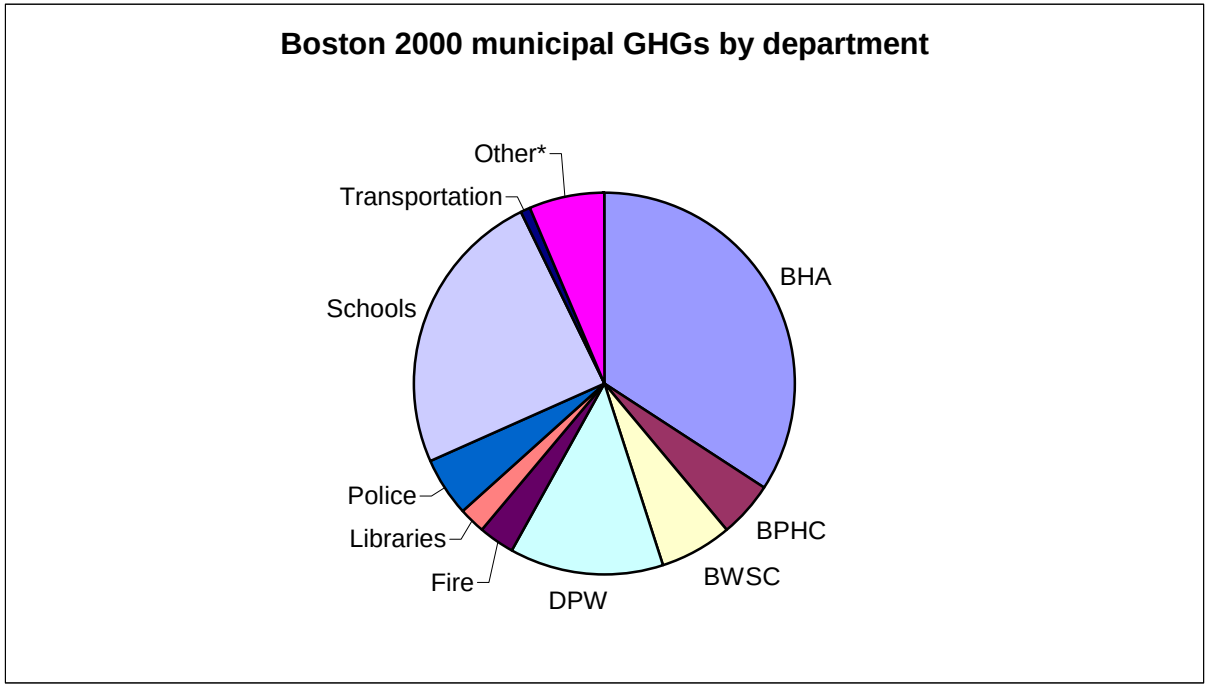

Boston 2000 municipal GHGs by department
Other*
Transportation
Schools
BHA
Police
Libraries
Fire
DPW
BWSC
BPHC

Figure 5a.

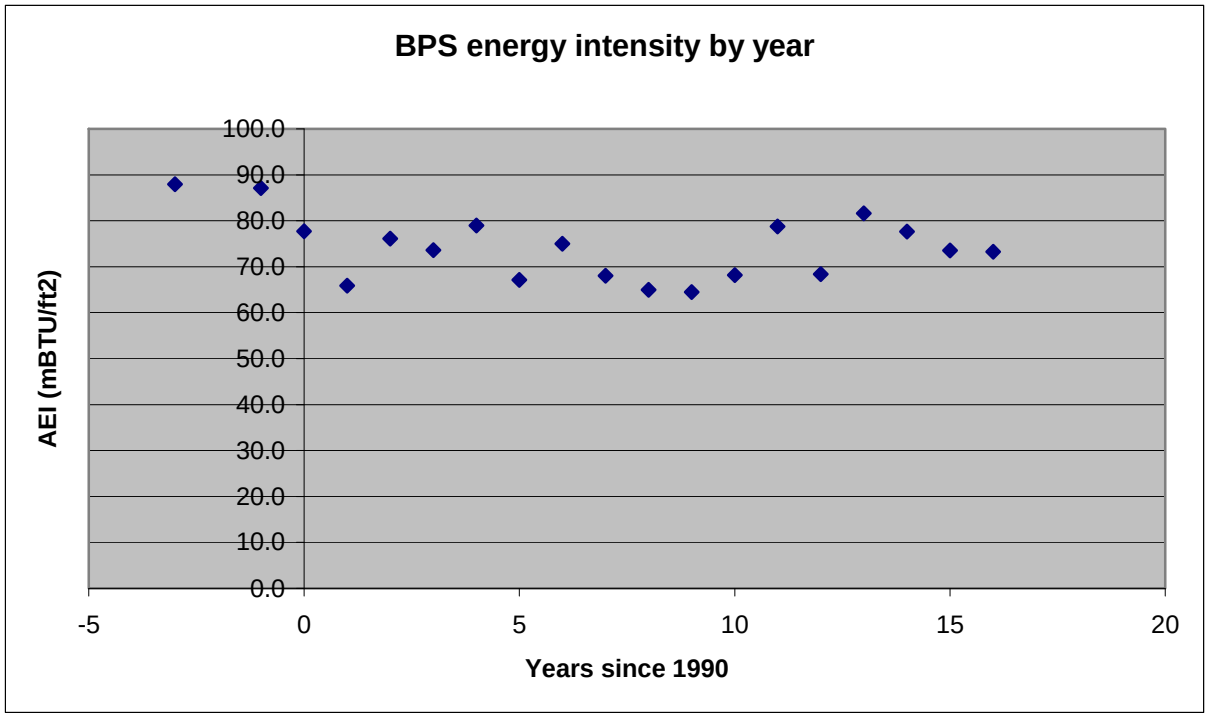
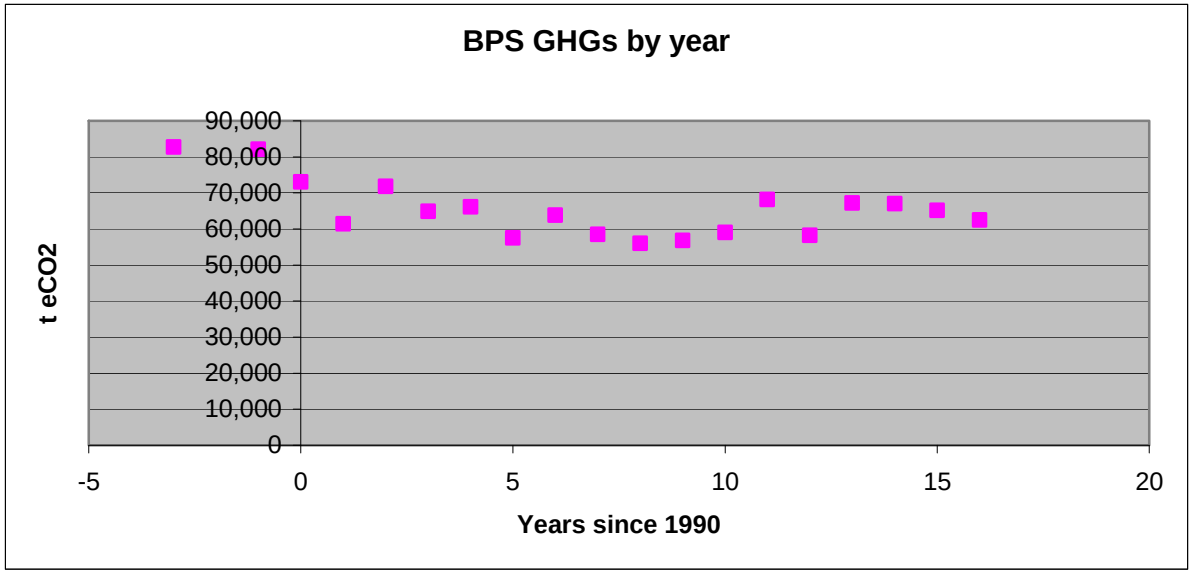

BPS energy intensity by year
AEI (mBTU/ft2)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-5
0
5
10
15
20
Years since 1990

Figure 5b.


BPS GHGs by year
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
t eCO2
-5
0
5
10
15
20
Years since 1990