

## **Introductory note**

The attached document is the original report containing Boston greenhouse gas inventories for 2000 and 2005, released in January 2008. The inventories for municipal operations have been revised and included in a new report along with the 2006 inventory. The 2005 community inventory will also require revision. The original report remains available so that interested persons can study the details of all changes. The City of Boston welcomes comments on its methodology.

Please see <http://www.cityofboston.gov/climate/progress.asp> for the most recent inventories.

## **2005 Boston Greenhouse Gas Inventories**

1. FY 2005 City of Boston Municipal GHG Emissions
2. 2005 Boston Community GHG Emissions
3. FY 2000 City of Boston Municipal GHG Emissions
4. Notes on the 2005 Boston Greenhouse Gas Inventories

## 2005 City of Boston Municipal GHG Emissions - in Equivalent CO<sub>2</sub> tons

CITY OF BOSTON DEPARTMENTS	BUILDINGS				TRANSPORT		ST.LIGHTS/WATER/SEWER			Subtotal	Percentage of Total	
	Electricity	Natural Gas	Light* Fuel Oil	Trigen Steam	Gasoline	Diesel**	Electricity	Natural Gas	Light*** Fuel Oil			
Boston Public Schools	26,038	38,572			366	14,416				79,392	26%	
Center for Youth and Families	1,292	3,031								4,323	1%	
Emergency Medical Services	143	258								401	0%	
Fire	2,064	2,715	610		895	2,221				8,505	3%	
Graphic Arts	71	261								332	0%	
Library	6,916	958	201	3,666						11,741	4%	
Neighborhood Development	108									108	0%	
Parks and Recreation	1,306	644	225		159	525				2,859	1%	
Police	4,275	2,957	620		4,756	3				12,611	4%	
Property Management	6,747	523	505	1,717						9,492	3%	
Public Works	1,439	2,515	147		5,062	2,309	27,155	2,760		41,387	14%	
Transportation	291	228	32							551	0%	
										<b>Department Subtotal</b>	<b>171,702</b>	<b>56%</b>
<b>INDEPENDENT AND QUASI-INDEPENDENT AUTHORITIES</b>												
Boston Housing Authority	26,714	47,097	6,705	696	420	22				81,654	27%	
MWRA (Boston share)					378	245	20,775	849	9,227	31,474	10%	
Public Health Commission	3,230	6,040	5,066							14,336	5%	
Redevelopment Authority	132	1,980	64							2,176	1%	
Water and Sewer Commission	1,792	873			850	783	507		90	4,895	2%	
										<b>Authority Subtotal</b>	<b>134,535</b>	<b>44%</b>
										<b>TOTAL BOSTON MUNICIPAL EMISSIONS</b>	<b>306,237</b>	<b>100%</b>

\*Includes 307 tons from propane for BPHC

\*\*Includes ULSD and biodiesel

\*\*\*BWSC figure is for stationary diesel

GHGs by Sector	eCO <sub>2</sub>	%
Buildings	211,464	69%
Transportation	33,410	11%
Water/Sewer	31,448	10%
Streetlights	29,915	10%

GHGs by Fuel	eCO <sub>2</sub>	%
Electricity	130,995	43%
Natural Gas	112,261	37%
Light fuel oil	23,095	8%
Diesel	20,614	7%
Gasoline	12,886	4%
Steam	6,079	2%
Propane	307	0%

## 2005 Boston Community GHG Emissions - in Equivalent CO<sub>2</sub> tons

### SUMMARY

<b>GHGs by Sector</b>	<b>eCO<sub>2</sub></b>	<b>%</b>
Residential	1,340,000	17
Commercial/Industrial	3,970,000	50
Transportation	2,290,000	29
Waste	100,000	1
Other	250,000	3
<b>TOTAL COMMUNITY EMISSIONS</b>	<b>7,950,000</b>	<b>100</b>

<b>GHGs by Fuel</b>	<b>eCO<sub>2</sub></b>	<b>%</b>
Electricity	2,790,000	35
Light Fuel Oil	800,000	10
Natural Gas <sup>^</sup>	1,660,000	21
Trigen Steam	280,000	4
Gasoline*	1,670,000	21
Diesel*	400,000	5
Other	250,000	3
Waste	100,000	1
<b>Total</b>	<b>7,950,000</b>	<b>100</b>

### SECTOR DETAILS

<b>Residential</b>	<b>eCO<sub>2</sub> (tons)</b>	<b>eCO<sub>2</sub> (%)</b>	<b>Energy (million Btu)</b>
Electricity	502,756	6.3	4,439,142
Light Fuel Oil	420,378	5.2	5,085,338
Natural Gas <sup>^</sup>	374,759	4.7	6,065,814
Trigen Steam	43,608	0.5	491,455
<b>Residential Total</b>	<b>1,341,501</b>	<b>16.7</b>	<b>16,081,749</b>

#### Commercial and Industrial

Electricity	2,083,943	26.0	18,400,418
Light Fuel Oil	383,433	4.8	4,638,418
Natural Gas <sup>^</sup>	1,231,709	15.4	19,936,301
Trigen Steam	237,861	3.0	2,680,664
<b>Subtotal</b>	<b>3,936,947</b>	<b>49.1</b>	<b>45,655,801</b>

#### Streetlighting

Electricity	32,234	0.4	284,615
<b>Total Comm/Industrial</b>	<b>3,969,181</b>	<b>49.5</b>	<b>45,940,416</b>

#### Transportation

Gasoline*	1,660,655	20.7	19,404,153
Diesel*	347,366	4.3	4,002,106
<b>Subtotal</b>	<b>2,008,021</b>	<b>25</b>	<b>23,406,259</b>

#### MBTA

Gasoline	4,986	0.1	58,257
Diesel	53,719	0.7	619,341
CNG	49,944	0.6	788,442
Electricity	172,811	2.2	1,525,853
<b>Subtotal</b>	<b>281,460</b>	<b>3.5</b>	<b>2,991,893</b>
<b>Transportation Total</b>	<b>2,289,481</b>	<b>28.5</b>	<b>26,398,152</b>

**Waste**

Paper Products	12,782	0.2
Food Waste	4,448	0.1
Plant Debris	4,896	0.1
Wood/Textiles	2,616	0
All Other Waste	75,795	0.9
<b>Waste Total</b>	<b>100,537</b>	<b>1.3</b>

**Other**

Education - Steam	11,893	0.1
Longwood Medical	80,631	1
Mass General	411	0
Mass Port	53,761	0.7
Medical - Steam	103,073	1.3
<b>Other Total</b>	<b>249,769</b>	<b>4</b>

**Notes**

Emissions calculated with ICLEI Clean Air and Climate Protection Software 2003

^Large residential units are included in Commercial and not Residential.

According to 2000 figures, residential makes up about 45% of natural gas consumption.

\*Based on Community VMT (vehicle miles traveled)

^^Disposal method - controlled incineration

10-Jan-08

## 2000 City of Boston Municipal GHG Emissions - in Equivalent CO<sub>2</sub> tons

CITY OF BOSTON DEPARTMENTS	BUILDINGS				TRANSPORT		ST.LIGHTS/WATER/SEWER			Subtotal	Percentage of Total	
	Electricity	Natural Gas	Light* Fuel Oil	Trigen Steam	Gasoline	Diesel	Electricity	Natural Gas	Light Fuel Oil			
Boston Public Schools	22,566	17,701	19,396	130	372	13,758				73,923	24%	
Community Centers	984	3,087								4,071	1%	
Emergency Medical Services					507					507	0%	
Fire	1,848	2,906	1,423		1,221	2,076				9,474	3%	
Graphic Arts	26	223								249	0%	
Library Department	2,539	733	1,247	1,964						6,483	2%	
Neighborhood Development	13	117								130	0%	
Parking	29									29	0%	
Parks and Recreation	1,183	384	548		911	500				3,526	1%	
Police	2,840	2,177	786	305	9,556					15,664	5%	
Property Management	3,855	411	580	1,881						6,727	2%	
Public Works	907	295	200	3,356	5,517	3,228	23,017	3,361		39,881	13%	
Transportation	2,393	204	53							2,650	1%	
										<b>Department Subtotal</b>	<b>163,314</b>	<b>53%</b>
<b>INDEPENDENT AND QUASI-INDEPENDENT AUTHORITIES</b>												
Boston Housing Authority	32,889	68,813	2,231							103,933	34%	
MWRA (Boston share)							14,892			14,892	5%	
Public Health Commission	2,972	4,339	6,499							13,810	5%	
Redevelopment Authority	1,478	3,645								5,123	2%	
Water and Sewer Commission	1,691	2,930					284	109		5,014	2%	
										<b>Authority Subtotal</b>	<b>142,772</b>	<b>47%</b>
<b>TOTAL BOSTON MUNICIPAL EMISSIONS</b>										<b>306,086</b>	<b>100.0%</b>	

\*Includes 164 tons from propane for BPHC

GHGs by Sector	eCO <sub>2</sub>	%
Buildings	226,777	74%
Transportation	37,646	12%
Water/Sewer	15,285	5%
Streetlights	26,378	9%

GHGs by Fuel	eCO <sub>2</sub>	%
Electricity	116,406	38%
Natural Gas	111,435	36%
Light fuel oil	32,799	11%
Diesel	19,562	6%
Gasoline	18,084	6%
Steam	7,636	2%
Propane	164	0%

## Notes on the 2005 Boston Greenhouse Gas Inventories

In his April 2007 executive order on climate action, Mayor Thomas Menino directed that the City would report annually on its greenhouse gas (GHG) emissions. To provide context to the current level of emissions and identify trends more clearly, the City is developing a series of reports on GHG emissions for the past several fiscal years. This report on the 2005 municipal and community GHG emissions is the first such report and the first complete inventory for municipal operations since fiscal year 2000 (FY00). The FY00 inventory is included for reference.

### GENERAL COMMENTS

In fiscal year 2005 (FY05), the City of Boston in its municipal operations, including independent and quasi-independent authorities, had net GHG emissions of about 300,000 tons of equivalent carbon dioxide (eCO<sub>2</sub>). This is roughly the same as the amount of emissions in the fiscal year 2000 inventory, and represents about four percent of the GHG emissions of the entire Boston community (8 million tons eCO<sub>2</sub>).

1. If both the 2000 and 2005 municipal inventories are roughly accurate, total GHG emissions and total energy purchases were about the same in those two years. Two agencies, however, had significant changes in the emissions.
2. The Boston Housing Authority (BHA), the largest single emitter in the municipal budget, reduced its GHG emissions by about 20 percent (about 22,000 tons) from FY00 to FY05. The reduction was due to three factors: efficiency upgrades on electrical and HVAC systems, sale of several large developments, and a large energy performance contract started in 2000. (See the Climate Action Plan for more information.)
3. The Massachusetts Water Resources Authority (MWRA) had the largest increase in GHG emissions, about 17,000 tons. Expansion in its operations—including enhanced secondary treatment of waste water, the opening of the [Deer Island outfall tunnel](#) in September 2000, and the opening of the [Carroll Water Treatment Plant](#) for drinking water ozonation in July 2005—increased the Authority’s energy demands beyond the [increase in renewable energy projects](#) in the same period.
4. The effects of weather on relative energy use in FY00 and FY05 were probably not significant. According to weather data from Logan Airport obtained through the [National Oceanic and Atmospheric Administration](#), FY05 was slightly cooler than FY00 (mean temperature 50.4°F vs. 52.4°F), with more heating degree-days (5,889 vs. 5,318), but fewer cooling degree-days (683 vs. 833).
5. Many technical and policy issues concerning the most appropriate way to calculate GHG inventories remain open. The City of Boston participates in a local working group to discuss these issues with the Commonwealth of Massachusetts, other municipalities,

local institutions, and ICLEI and other NGOs. Similar discussions are occurring at national and international levels. These inventories may be subject to revisions.

6. The municipal inventory was overseen by staff of the Boston Air Pollution Control Commission, and the community inventory by staff of ICLEI's Northeast Regional Capacity Center, located in Boston, with extensive consultation, coordination, and collaboration between the two groups. However, these inventories could not have been completed nor achieved whatever level of accuracy they have without a large amount of work, cooperation, and guidance from colleagues in many City departments, the independent authorities, several ICLEI offices, Boston's energy utilities, and several local institutions.

7. *For more information.* Please direct any comments or questions about the inventories to Carl Spector, Executive Director, Air Pollution Control Commission, [carl.spector@cityofboston.gov](mailto:carl.spector@cityofboston.gov).

## TECHNICAL NOTES

### General

8. *Software.* To calculate greenhouse gas 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 STAPPA/ALAPCO). The CACP software contains fuel-specific, region-specific, and, in some cases, use-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 CO<sub>2</sub>).

9. *Emission factors—electricity.* The CACP software uses an emission factor for electricity based on the mix of generators overseen by the [Northeast Power Coordinating Council](#), which encompasses New England, New York and Eastern Canada Provinces. The energy mix for electricity in this region in summer 2007 was 37% hydro, 16% dual fuel, 15% nuclear, 14% natural gas, 9% coal, 6% oil, and 3% other.

10. *Time frame.* The municipal inventory is based on the City's fiscal year, July 1 to June 30. The community inventory is based on the calendar year.

11. *Units.* The current inventories' unit of measurement is tons (short tons) of [equivalent carbon dioxide \(eCO<sub>2</sub>\)](#). Many other reports use metric tons or tonnes: 1 ton = 0.907 metric tonne.

### Municipal inventory

12. *Scope.* The municipal inventory is divided into two large categories: (1) City of Boston Departments and (2) Independent and Quasi-Independent Authorities. The first



category includes all operational departments over which the Mayor has direct control. The second category includes authorities and commissions, with the exception of the Massachusetts Water Resources Authority (MWRA), over which the Mayor may have some combination of direct authority and the power of appointment. The MWRA is a state authority, and provides significant services (water and sewer) for the city of Boston. The municipal inventory does not include GHGs associated with official airplane travel nor with employee commuting.

13. *Data sources—departments.* Data on electricity and natural gas purchases by department come from the computerized Major Vendor System maintained by the Office of Budget Management. The Major Vendor System compiles monthly bills submitted by the City's electricity and natural gas suppliers. Data on gasoline, diesel, and fuel oil, and steam come from the Purchasing Department's list of invoices received for deliveries. Trigen Energy supplied the data on the City's steam consumption. The GHGs were allocated to fiscal year by the data of delivery; no attempt was made to determine when fuel was actually used. The FY05 inventory includes some changes in department names and some consolidation of accounts.

14. *Data sources—authorities.* All five authorities have independent budgets and maintain their own accounts for energy use. They transmitted their annual energy purchases to the APCC, which performed the GHG calculations.

15. *MWRA allocation.* The Massachusetts Water Resources Authority provides water and sewer services to 2.5 million people and more than 5,500 businesses in 61 communities in eastern and central Massachusetts. Based on measurements of actual flows in FY05, MWRA allocated to Boston 11.8 percent of the energy associated with the water supply system and 20.1 percent of the energy associated with the sewer system.

16. *Verification.* The City of Boston municipal inventory has not received third-party verification. In general, existing verification frameworks require facility-specific data by calendar year. The City intends to develop the detail of its inventory to this level in the next several years and then obtain verification.

## **Community inventory**

17. *Approach.* The community inventory mixes top-down and bottom-up inventory methods and estimates based on models. It is not expected to have the same degree of precision as the municipal inventory, which is based on actual energy purchases. For this reason, the summary figures are rounded off (and perhaps should have been rounded one level further), although the sector details show the exact calculations behind them.

18. *Scope.* The goal of the community inventory is to include all GHG emissions associated with all activities—residential, commercial/industrial, institutional, transportational—within city boundaries. Most government activity is in the commercial/industrial category.

19. *Natural gas.* Data on natural gas consumption in Boston was provided by [Keyspan](#), now part of National Grid. Keyspan reported natural gas sales in two categories according to account type—residential (types 3801–3832) and commercial/industrial (types 3841–3984). However, large residential sites—that is, those with more than four or more units that are separately metered—are included in the commercial/industrial category. (This is true only for natural gas, not for electricity.)

20. *Electricity.* Data on electricity consumption in Boston was provided by [NStar](#). NStar reported electricity sales according to rate type—residential (types R1–R4) and commercial/industrial (types G1-G3, T1-T2, and S1-S3; these last rates are for street lighting).

21. *Steam.* Boston’s largest steam plant is run by [Trigen Energy](#), which provided data on actual fuel use and on steam supplied by category (residential, commercial, medical, and education). The actual fuel used (by energy content, 88.4% heavy fuel oil, 2.6% light fuel oil, and 9.0 % natural gas) was used to calculate a GHG emission factor specifically for this source.

22. *Residential fuel oil.* According to the [Massachusetts Energy Consumers Alliance](#), the average Massachusetts household using fuel oil used 866.5 gallons in the 2004-2005 heating season and 742.7 gallons in 2005-2006. We averaged these to numbers to estimate 804.6 gallons per household for the 2005 calendar year. The [U.S. Census Bureau](#) estimates that 45,159 households in Boston used fuel oil as their primary heating source in 2005. Multiplication of these two numbers gives an estimate of 36,334,931 gallons of heating oil for the residential sector of the Boston community.

23. *Commercial/industrial fuel oil.* According to the federal [Energy Information Administration](#), buildings in the Northeast that used fuel oil used an average of 0.2 gallons per square foot for heating in 2003. A [2003 Department of Energy study](#) found that about 52 percent of commercial structures used fuel oil. The City of Boston’s [Assessing Department](#) determined that, in 2005, there were 318,669,896 square feet of commercial/industrial building space in Boston. Multiplication of these three numbers gives an estimate of 33,141,669 gallons of heating oil for the commercial/industrial sector of the Boston community.

24. *Transportation.* The Commonwealth’s [Central Transportation Planning Staff](#) (CTPS), based on models, estimated or projected the total daily number of miles traveled by all vehicles, except transit vehicles, in Boston in 2000 and in 2010. The average of these two figures gave an estimate for 2005 vehicle miles traveled (VMTs) of 3,054,403,935 miles. The CACP software used this data with its regional default for the distribution of vehicle types to estimate GHG emissions.

25. *MBTA fuel usage.* The MBTA provided data on its 2005 system-wide usage of gasoline, diesel fuel, electricity, and natural gas for all vehicles, though not broken down by vehicle type, which the CACP software requires. Therefore, for the sake of estimation,

all gasoline was assigned to passenger vehicles, and all diesel fuel and natural gas to transit buses.

26. *Waste*. The waste figure is an estimate of GHG emissions from the disposal of all non-hazardous waste—residential, commercial, industrial, and institutional—generated in Boston. A 2005 [EPA study on municipal solid waste](#) found that the United States generates about 4.5 lbs of waste per person per day. Multiplying this by Boston’s 2005 population and then by 365 gives a total 2005 waste generation of 463,188 tons. According to the City’s Department of Public Works, total municipally controlled waste—that is, residential waste and waste from municipal buildings—was 253,129 tons, which is consistent with the EPA study’s finding that municipal and residential waste accounts for 55 to 65 percent of total waste. DPW has little control over waste disposal technology, but believes that most Boston waste is incinerated. Therefore, the emissions number was calculated for the incineration of 463,188 tons.

27. *Other*. The category Other includes institutions—hospitals, universities, Massport—that produce their own power for internal use. There may be some double-counting in this category. For example, some of the institutional power plants use natural gas, which may already have been accounted for in the natural gas consumption reported by Keyspan. Because the total GHG emissions from Other is relatively small and there are other important components in this category, the possible double-counting is not significant to the overall community inventory. If further data become available, there may be corrections to this part of the inventory.

28. *Longwood Medical*. Data on GHG emissions by energy source for this entity were provided by the [Harvard Green Campus Initiative](#). About three-quarters of the emissions come from operation of the Medical Area Total Energy Plant. Harvard requested that we use its calculated emission numbers, and we have done so. The emission factors that Harvard uses are different than those in the CACP software, particularly for electricity. If the CACP software were used, total emissions would be less. However, Harvard also purchased carbon offsets representing the equivalent of 8,487 metric tonnes of eCO<sub>2</sub>, which it also requested that we include. Harvard is a member of the local working group discussing inventory methodologies, mentioned in note #5.

29. *Massachusetts General Hospital*. MGH provided data on the total natural gas consumption of one 60 kW co-generation unit in operation from 2000 to 2005. This was divided by six to estimate annual consumption.

30. *Massport*. Massport’s 2005 annual report includes data on energy use at Logan Airport. The community inventory includes only emissions from stationary sources; in particular, aviation fuel is not counted in the current inventory. At the moment, the CACP protocol leaves this decision up to each municipality. If aviation fuel were included, it would add another 4 million tons of eCO<sub>2</sub> to the community total, a 50-percent increase. The inventory also does not include emissions from Massport’s marine operations.

January 10, 2008