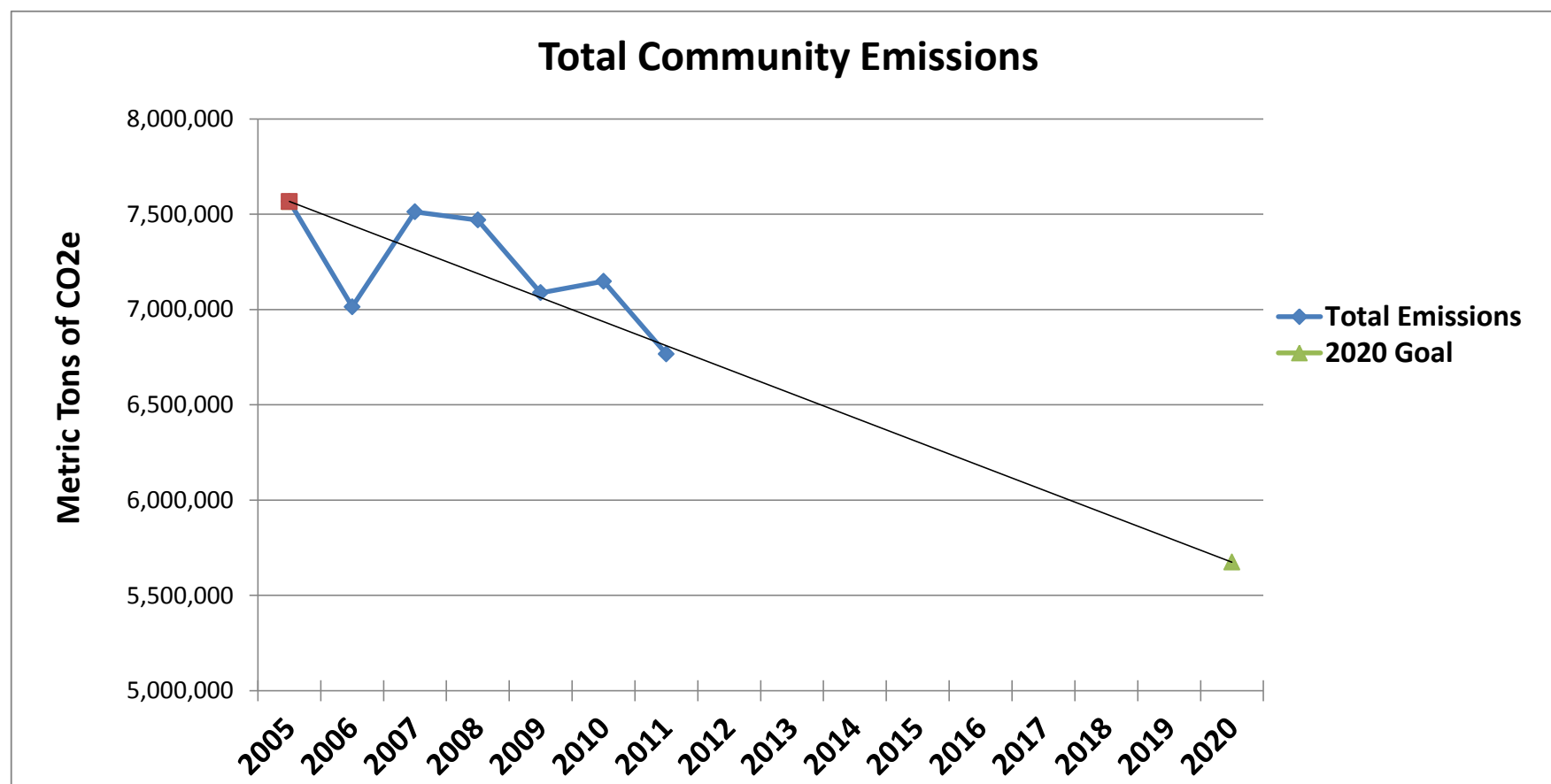


Boston Community Greenhouse Gas Inventories

1. GHG inventory summary 2005–2011
2. GHG emissions 2006–2011
3. Energy use 2006–2011
4. Notes

Boston Community Greenhouse Gas Inventory In Metric Tons CO2 Equivalent

	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>
Residential	1,339,000	1,190,000	1,314,000	1,327,000	1,265,000	1,324,000	1,197,000
Commercial/Industrial	4,071,000	3,721,000	4,071,000	4,019,000	3,728,000	3,729,000	3,494,000
Transportation	2,124,000	2,073,000	2,097,000	2,096,000	2,070,000	2,068,000	2,052,000
Water and Sewer	32,000	30,000	31,000	27,000	25,000	27,000	23,000
Total Emissions	7,567,000	7,014,000	7,512,000	7,469,000	7,088,000	7,148,000	6,767,000
Reduction from 2005	0%	-7%	-1%	-1%	-6%	-6%	-11%
Emissions per capita	12.9	11.9	12.7	12.4	11.6	11.6	10.8



Boston Community Greenhouse Gas Inventory

In Metric Tons CO2 Equivalent

	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>	<u>2011</u> <u>Percentage</u>
Residential							
Electricity	459,436	516,206	505,422	462,931	495,967	467,626	
Natural Gas	299,733	375,583	406,752	389,173	435,192	418,496	
Fuel Oil	358,413	355,010	353,023	354,283	340,412	254,869	
Steam	27,097	24,418	22,733	21,030	16,346	20,247	
Waste	45,521	42,937	39,272	37,615	36,264	35,916	
Subtotal	1,190,000	1,314,000	1,327,000	1,265,000	1,324,000	1,197,000	18%
Commercial/Industrial							
Electricity	1,999,547	2,284,607	2,242,970	2,044,722	2,072,803	1,944,394	
Natural Gas	1,022,985	1,109,626	1,126,827	1,087,287	1,096,933	966,401	
Fuel Oil	352,788	345,363	338,066	330,896	323,852	316,933	
Steam	219,239	197,560	183,932	154,220	132,258	163,819	
Waste	125,963	134,071	127,050	110,935	102,912	102,912	
Subtotal	3,721,000	4,071,000	4,019,000	3,728,000	3,729,000	3,494,000	52%
Transportation							
Community							
Gasoline	1,537,116	1,529,304	1,523,191	1,516,632	1,511,333	1,501,680	
Diesel	298,879	299,155	299,899	300,643	301,386	302,130	
MBTA							
Electricity	149,625	176,484	176,484	162,301	162,403	153,071	
Diesel	49,657	53,905	58,672	57,975	62,274	61,736	
CNG	33,296	33,296	33,296	28,309	26,601	29,289	
Gasoline	4,176	4,370	4,298	4,065	3,916	4,055	
Subtotal	2,073,000	2,097,000	2,096,000	2,070,000	2,068,000	2,052,000	30%
Water and Sewer							
Electricity	20,441	23,815	23,451	20,585	19,424	18,721	
Natural Gas	784	902	762	911	702	815	
Fuel Oil	8,221	5,219	2,110	3,259	6,389	2,898	
Gasoline	300	286	338	342	357	308	
Diesel	288	335	346	352	432	397	
CNG	4.07	4.26	0.41	0.13	0.00	1.32	
Subtotal	30,000	31,000	27,000	25,000	27,000	23,000	0.3%
Total Emissions	7,014,000	7,512,000	7,469,000	7,088,000	7,148,000	6,767,000	

<u>GHG Emissions by Fuel</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>	<u>2011 Share</u>
Electric	2,629,000	3,001,100	2,948,300	2,690,500	2,750,600	2,583,800	38%
Natural Gas	1,356,800	1,519,400	1,567,600	1,505,700	1,559,400	1,415,000	21%
Fuel Oil	719,400	705,600	693,200	688,400	670,700	574,700	8%
Steam	246,300	222,000	206,700	175,200	148,600	184,100	3%
Gasoline	1,541,600	1,534,000	1,527,800	1,521,000	1,515,600	1,506,000	22%
Diesel	348,800	353,400	358,900	359,000	364,100	364,300	5%
Waste	171,500	177,000	166,300	148,600	139,200	138,800	2%

Boston Community Energy Data*

	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>
<u>Residential</u>						
Electricity (kWh)	1,247,372,559	1,251,947,232	1,246,359,067	1,226,647,553	1,312,607,886	1,314,950,213
Natural Gas (therms)	56,385,947	70,654,924	76,518,407	73,211,483	81,868,501	78,727,667
Fuel Oil (gals)	34,902,299	34,570,853	34,377,420	34,500,054	33,149,283	24,819,157
Steam (klbs)	239,740	264,380	243,269	272,122	246,189	246,189
Waste (tons)	245,311	226,910	220,777	208,886	201,385	199,449
<u>Commercial/ Industrial</u>						
Electricity (kWh)	5,428,782,998	5,540,827,008	5,531,118,810	5,417,986,149	5,485,799,351	5,467,579,949
Natural Gas (therms)	192,444,503	208,743,460	211,979,363	204,541,105	206,355,685	181,800,026
Fuel Oil (gals)	34,354,535	33,631,482	32,920,893	32,222,670	31,536,713	30,862,912
Steam (klbs)	1,939,713	2,139,074	1,968,264	1,995,564	1,991,896	1,991,895
Waste (tons)	678,806	708,526	714,247	616,052	571,495	571,495
<u>Transportation</u>						
Vehicle Miles Traveled	3,074,692,556	3,082,355,782	3,090,019,008	3,097,682,234	3,105,345,460	3,113,008,686
<u>MBTA</u>						
Electricity (kWh)	406,231,550	428,025,310	435,207,000	430,057,000	429,810,000	430,431,000
Diesel (gals)	4,858,819	5,274,388	5,740,865	5,672,654	6,093,331	6,040,630
CNG (therm)	5,757,670	5,757,670	5,757,670	4,895,180	4,599,820	5,064,750
Gasoline (gals)	465,613	487,285	479,220	453,237	436,577	452,068
<u>Water and Sewer (Fiscal Yr)</u>						
Electricity (kWh)	55,497,115	57,758,822	57,830,005	54,545,995	51,406,925	52,641,791
Natural Gas (therms)	147,511	169,605	143,441	171,314	132,043	153,401
Fuel Oil (gals)	800,528	508,250	205,474	317,363	622,135	282,229
Gasoline (gals)	33,433	31,870	37,680	38,078	39,839	34,339
Diesel (gals)	28,193	32,787	33,890	34,465	42,282	38,861
CNG (therms)	639	669	65	21	0	207

*The numbers for fuel oil, waste, and vehicle miles traveled are based on models or incomplete data. Please see notes.

Notes

1. In his April 2007 executive order on climate action, Mayor Thomas Menino directed that the City would report annually on Boston's greenhouse gas (GHG) emissions. This report extends the annual community inventories through 2011. It also includes adjustments to the earlier inventories based on revised data and emission factors. Greenhouse gas emissions specifically from municipal operations of the City of Boston are described in a separate report, but are included in the community totals. This report covers 2006-2011. Data for 2005 are available in the Archive section on our website.
2. Boston GHG inventories are overseen by staff of the Boston Air Pollution Control Commission. 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 and independent authorities, several departments of the Commonwealth of Massachusetts, ICLEI, Boston's energy utilities, and a variety of local institutions.
3. Please direct comments or questions about the inventories to Haidee Janak, Program Manager, Air Pollution Control Commission, haidee.janak@cityofboston.gov. Suggestions for improving the accuracy or completeness of the inventory are welcome.
4. *Scope.* The goal of the community inventory is to include GHG emissions associated with all activities—residential, commercial/industrial, institutional, transportation-related—within city boundaries. Most government activity is in the commercial/industrial category. The inventory does not currently include emissions from, among other things, airplane travel at Logan Airport, the complete life cycle of consumer products, or fugitive natural gas.
5. *Approach.* The community inventory mixes top-down and bottom-up inventory methods and estimates based on models. It cannot have the same degree of precision as the municipal inventory, which is based on actual energy purchases. For this reason, the totals are rounded off.
6. *Time frame.* The community inventory is based on the calendar year, except for water and sewer data, which are based on the fiscal year. The municipal inventory is based on the City's fiscal year, July 1 to June 30.
7. *Units.* The inventories' unit of measurement, until this release, was tons (short tons) of carbon dioxide equivalent (CO₂e). In conformance with common practice, we have now switched to metric tons or tonnes. 1 short ton = 0.907 metric tonne.
8. *Emission factors (energy to GHGs).* The municipal and community GHG inventories use the annual electricity emission factors calculated by ISO-New England, the regional transmission organization. The ISO-NE electricity emission factor is usually several percent lower than the factor used by the Commonwealth of Massachusetts for the statewide GHG emissions inventory, which is based primarily on power plants located in Massachusetts. Both factors can vary from year to year according to the actual fuel mix used to produce electricity. The January 2013 version of this inventory used the 2010 ISO-NE emission factor for 2011 electricity; the May version uses the new 2011 emission factor released by ISO-NE. All other emissions factors—except steam's (see #11 below)—come from GHG inventory tools released by ICLEI- Local Governments for Sustainability and the National Association of Clean Air Agencies.

9. *Natural gas.* Data on natural gas consumption in Boston were provided by National Grid. National Grid reported natural gas sales in two categories according to account type—residential (types 3801–3832; 3901–3932) and commercial/industrial (types 3841–3853; 3941–3984). National Grid charges large residential sites—that is, buildings with more than four units that are not separately metered—a commercial rate; consequently, they are included in the commercial/industrial category. (This is true only for natural gas, not for electricity.) Natural gas used by Veolia steam plants is subtracted from the National Grid data to prevent double counting. Inventory emissions related to natural gas do not currently include leaks from the natural gas distribution system in Boston, and we are continuing to study this issue.
10. *Electricity.* Data on electricity consumption in Boston were provided by NStar. For 2005 and 2006, 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). For 2007–2011, NStar reported only the totals for residential and commercial/industrial, without a breakdown of the various rate types.
11. *Steam.* Veolia Energy provided data on steam supplied by category (residential, commercial, medical, and educational). Veolia also provided an annual emissions factor based on guidance from MassDEP and the federal Energy Information Administration (EIA). The EIA emissions coefficients (for natural gas and other fuels) vary slightly from the emissions factors used in the inventory’s direct calculations.
12. *Residential fuel oil.* We estimated residential fuel oil use by multiplying the average fuel oil use per household, by the estimated number of households using fuel oil in Boston. The household consumption data come from Mass Energy Consumers Alliance, a non-profit energy organization with 15,000 residential customers in eastern Massachusetts, 3,000 of who are in Boston. The Mass Energy data are according to heating season, so we took the average of consecutive seasons as representative of a calendar year. The U.S. Census Bureau provides the estimated number of households that use heating oil in Boston. Mass Energy estimates that their members use four to seven percent less fuel oil than average Massachusetts residents, so actual emissions from Boston residential oil use may be higher than those given. At the same time, Boston’s urban housing mix, which includes many multi-family houses and apartment buildings, could result in lower than average heating needs in many homes. Although Mass Energy’s coverage area includes most of Eastern Massachusetts, the data provided to us does not include dealers who don’t serve the Boston area at all.
13. *Commercial/industrial fuel oil.* We estimated commercial fuel oil use by multiplying together four factors from different sources: a) average fuel oil use per square foot, b) amount of commercial/industrial space, c) percentage of commercial structures using fuel oil, and d) a factor to account for the long-term decline of fuel oil use.
 - a. According to the federal Energy Information Administration, buildings in the Northeast that used fuel oil used an average of 0.22 gallons per square foot for heating in 2003.
 - b. A 2003 Department of Energy study found that about 52 percent of commercial structures used fuel oil.
 - c. The City of Boston’s Assessing Department determined that, in 2005, there were 318.6 million and, in 2009, 330.5 million square feet of commercial/industrial building space in Boston. The total area of commercial space for subsequent years is extrapolated from these two data points.
 - d. In 2009, the Commonwealth of Massachusetts released its report *Statewide Greenhouse Gas Emissions Level*, and support documents, which showed that statewide commercial fuel oil consumption dropped about five percent a year between 1990 and 2007. For Boston, we applied a smaller, three percent annual reduction, and assumed that this trend continued.

14. *Transportation.* The Commonwealth’s Central Transportation Planning Staff (CTPS) has developed a computer model to estimate the number of miles traveled by all vehicles, except transit vehicles, on a high-traffic mid-week day in eastern Massachusetts in 2000 and 2010. At our request, CTPS used the same model to estimate daily vehicle miles traveled (VMTs) in Boston for 2000 and 2010. To calculate annual VMTs, CTPS recommended a multiplier of 340, taking into account the weekend, holiday, and summer traffic patterns. We then used a linear interpolation between the 2000 and 2010 numbers to estimate VMTs for 2005 through 2009. VMTs for 2011 are calculated by a continuation of the same trend. CACP software translated VMTs into annual GHG emissions by using the national fleet mix to determine the distribution of vehicle types and assigning to these vehicle types a representative emissions factor. We are investigating methods for estimating emissions factors for a more localized fleet mix. Because the CACP software did not contain VMT emissions factors for 2011, we extrapolated the 2005–2010 trend to estimate 2011 factors that reflect continuing improvements in vehicle efficiency. The table below shows average fuel efficiency for all vehicles, according to the Environmental Protection Agency. The average pounds per vehicle mile are calculated using the CACP national fleet mix and associated emissions factors.

	2006	2007	2008	2009	2010	2011
Average miles per gallon	20.1	20.6	21.0	22.4	22.6	22.8
Average lbs CO ₂ e per vehicle mile-gas	1.102	1.094	1.087	1.079	1.073	1.063
Average lbs CO ₂ e per vehicle mile-diesel	0.526	0.526	0.526	0.526	0.526	0.526

15. *MBTA fuel usage.* The MBTA provided data on its annual system-wide usage of gasoline, diesel fuel, electricity, and natural gas. Electricity includes usage for both transit vehicles and buildings. Starting in 2008, the MBTA was able to separate natural gas usage for vehicles and buildings. We used the 2008 natural gas usage by vehicles as an estimate of 2005 to 2007 vehicle usage. The MBTA’s natural gas use in buildings is included in the Commercial/Industrial sector.
16. *Waste.* The waste figure is an estimate of GHG emissions from the disposal of all non-hazardous, non-recycled waste—residential, commercial, industrial, and institutional—generated in Boston.
- According to the City’s Department of Public Works (DPW), residential waste and waste from municipal buildings (MSW)—collection of which is managed by the City—amounted to about 199,500 tons in 2011. DPW has little control over waste disposal technology, but believes that most of Boston’s waste is incinerated.
 - We changed our method of estimating Boston’s amount of commercial waste in 2010. The current method starts with annual statewide data on non-diverted municipal solid waste (MSW), and non-MSW waste as reported by the Massachusetts Department of Environmental Protection (DEP). Non-MSW waste consists of construction and demolition debris from buildings, roadways, and bridges, as well as hazardous waste such as contaminated soil, asbestos-containing material, sludge, etc. Prior to 2009, DEP provided separate statewide totals for residential and commercial waste, but, starting in 2009, combined them. We have assumed that the residential/commercial split remains roughly the same as it was in 2008. We calculated Boston’s share by multiplying the commercial number by Boston’s proportion of total Massachusetts employment, based on data from the Massachusetts Executive Office of Labor and Workforce Development and the U.S. Bureau of Labor Statistics. DEP has not yet released new data for 2011, so the 2010 number is being repeated as a placeholder.

The previous methodology was based on sector-specific waste disposal rates per employee, as determined by DEP in 2002, and on annual Boston employment by sector. For consistency, we have recalculated the 2005-2009 waste generation figures using the new method and have modified earlier annual inventories. The new calculations produced slightly higher figures for 2006-2008, but a lower one for 2009.

17. *Water and Sewer.* The Massachusetts Water Resources Authority and the Boston Water and Sewer Commission both provide service for Boston. The water and sewer category here includes only the MWRA; see the municipal inventory for separate BWSC emissions, which are incorporated into the commercial/industrial category of the community inventory. The MWRA provides water and sewer services to 2.5 million people and more than 5,500 businesses in 61 communities in eastern and central Massachusetts. At our request, the MWRA allocated to Boston its pro rata share of its total annual energy used based on measurements of actual water and sewer flows. Boston accounts for about one-third of MWRA system usage. Because of a few MWRA buildings that likely fall under the utilities' classification for accounts that they report to us directly, there may be some double counting of electricity and natural gas use, but we think that it is negligible.
18. *Per capita emissions.* We calculated three types of per capita emissions using the most recent series of population and employment estimates by the U.S. Census Bureau, the Boston Redevelopment Authority, and the State's Executive Office of Labor and Workforce Development. Because of the results of the 2010 decennial census, there are some significant differences between the population numbers in this report and those of previous years. The per capita figures on page 2 are derived by dividing the total GHG emissions from all counted sources by Boston's residential population. Because the large number of people who commute into Boston for work and school make Boston's typical weekday population about twice the residential population, we did a separate residential emissions per capita (total residential emissions divided by residential population) and C/I emissions per employee (total commercial/industrial emissions divided by number of Boston employees). Transportation and Water and Sewer emissions are not part of the latter two calculations.

	2006	2007	2008	2009	2010	2011
Residential population	587,816	593,136	600,685	612,669	617,594	625,087
Residential emissions per resident (metric tons)	2.0	2.2	2.2	2.1	2.1	2.0
Boston employees	548,831	562,720	568,204	550,653	549,412	561,126
C/I emissions per employee (metric tons)	6.8	7.2	7.1	6.8	6.8	6.4

19. *Other emissions; other methods.* As mentioned in an earlier note, the inventory does not include emissions from airplane travel at Logan Airport. An order-of-magnitude calculation based on average airline travel by U.S. residents suggests that the inclusion of emissions from airplane travel by Boston residents would add on the order of one million tons of CO₂e to the annual inventory. The inventory also does not include emissions associated with the production, transportation, and waste disposal of all food and other goods consumed by a community. We made another order-of-magnitude calculation using average consumption data from the U.S. Consumer Expenditures Survey conducted by the Bureau of Labor Statistics and emissions factors from the Berkeley Institute of the Environment, University of California, Berkeley. This calculation suggests that life-cycle emissions from consumption in Boston are on the order of five million tons CO₂e. Both of these calculations are very rough and could easily vary, up or down, by a factor of 2 or more. Comments on this paragraph are particularly welcome.