



CITY OF BOSTON  
GREENHOUSE GAS EMISSIONS INVENTORY  
2005-2015

*February 8, 2018*





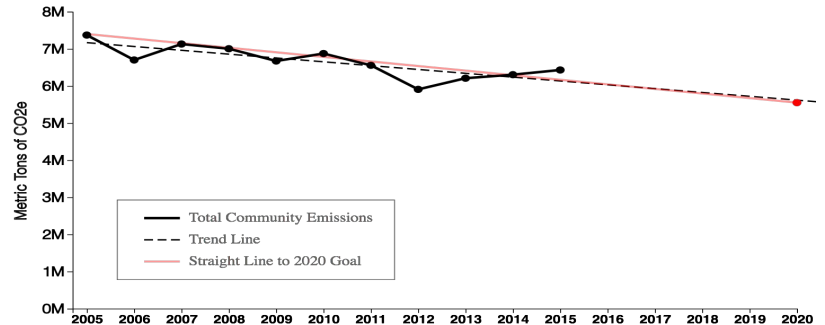
# CITY OF BOSTON GREENHOUSE GAS EMISSIONS INVENTORY 2005-2015

## OVERVIEW

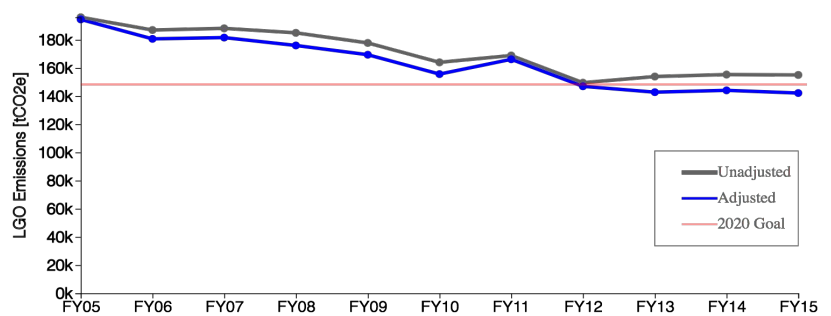
In 2015, the Boston community emitted 6.4 million metric tons of greenhouse gases (GHGs) from energy use in buildings and other facilities, and for transportation. This is a 2% increase from 2014, and an almost 13% decrease from 2005, Boston's GHG baseline. This reduction has occurred at the same time that the population and the number of jobs in Boston have increased.

Boston Local Government Operations emitted 142 thousand metric tons of GHGs, 27% net reduction from 2005 including renewable energy credits. The City of Boston met our municipal 2020 goal of reducing GHG emissions 25% below 2005 levels 5 years ahead of schedule.

### BOSTON COMMUNITY GHG EMISSIONS



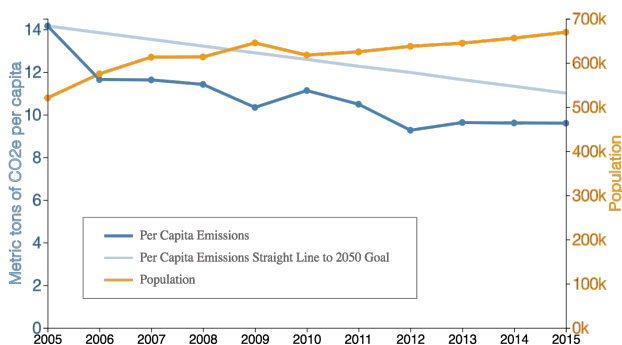
### LOCAL GOVERNMENT OPERATIONS EMISSIONS



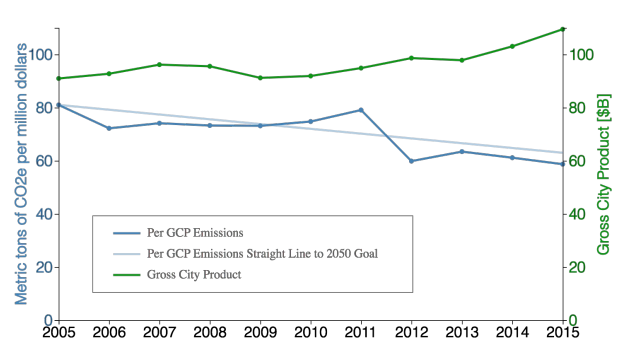
## ECONOMIC & POPULATION GROWTH

Boston is a metropolitan hub, with an international airport and a daytime population that doubles each weekday. Since 2005 the Boston community has grown from 520 thousand to nearly 670 thousand residents in 2015<sup>3</sup>, and Boston's economic growth, as measured by Gross City Product (GCP) has increased from 91 billion dollars to 109.5 billion<sup>4</sup>. Emissions per Boston resident over the same time period have decreased 32.2%, from 14.1 metric tons per year, to 9.6 metric tons. Emissions per million dollars of GCP have decreased 27.5%, from 81 metric tons per million dollars to 58.7 metric tons per million dollars.

### BOSTON PER CAPITA EMISSIONS



### BOSTON EMISSIONS PER GROSS CITY PRODUCT






To download the data directly, visit <https://data.boston.gov/dataset/greenhouse-gas-emissions>

**BACKGROUND**

In his 2017 [State of the City](#)<sup>1</sup> address, Mayor Martin J. Walsh announced the city’s goal of carbon neutrality by 2050. To measure progress, Boston follows the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories ([GPC](#))<sup>2</sup>. The baseline year is 2005, the first year in which consistent and reliable data was collected. Boston has an interim goal of 25% reduction in citywide emissions by 2020.

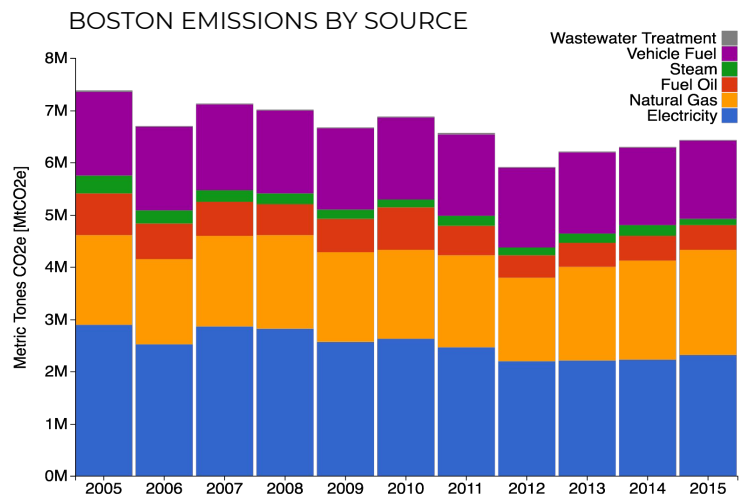
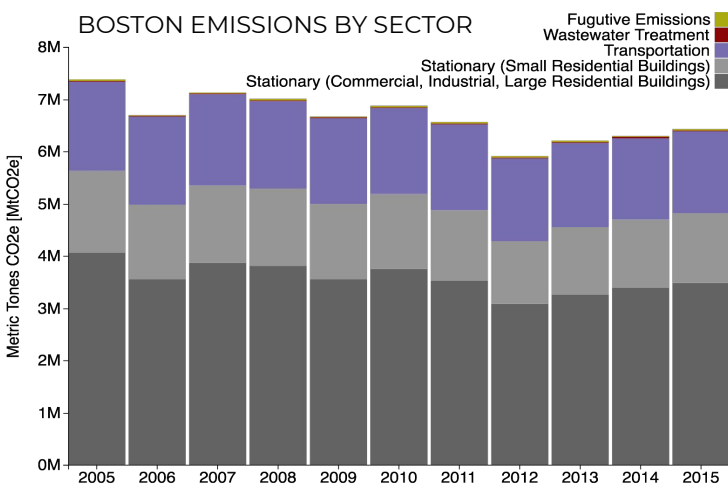
The annual GHG inventory is based on a combination of direct data and estimates for data that cannot be obtained directly. Data sources vary, and include City records, utility company reports, and information from state and federal agencies. Reporting is separated into community-wide and local government operations inventories. Because the data for these inventories is collected using separate protocols on separate timescales, the Local Government Operations Inventory should be considered to be overlapping, but not completely contained within the Citywide Inventory. Detailed notes on inventory methodologies can be found in Appendix I.

The *Greenovate Boston* [2014 Climate Action Plan](#) Update details strategies and actions for reaching the city’s goals.

<p><b>WHAT'S INCLUDED?</b></p>		<p>Energy used by buildings and other stationary sources; fugitive emissions from natural gas distribution within Boston limits</p>		<p>On-road and some off-road transportation, and public transportation trips within city limits.</p>		<p>Wastewater treatment within city limits.</p>
<p><b>WHAT'S NOT?</b></p>	<p>Emissions generated outside the city boundary to produce good or services used by residents (for example, emissions from food produced elsewhere but consumed by Bostonians). Boston will continue to evaluate the benefits and challenges of “consumption-based” emissions accounting as a complement to the current inventory methodology.</p>					

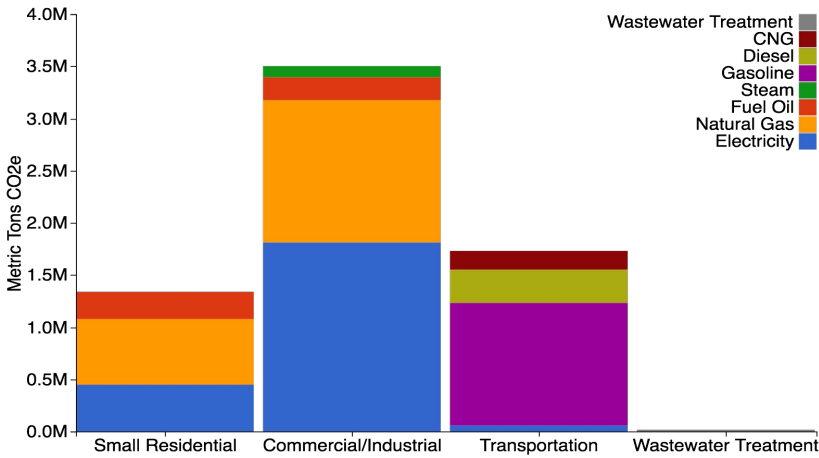
**EMISSIONS BY SECTOR & SOURCE**

This report contains details of GHG emissions and energy use from 2005 to 2015 by energy source and sector. GHG levels reflect both the quantity of energy used and the source of that energy.

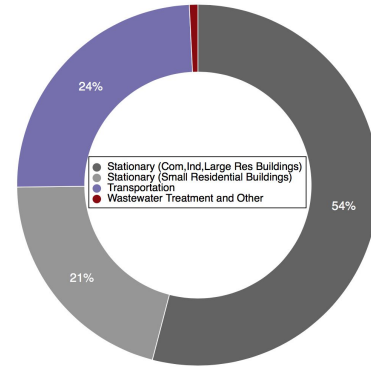




2015 EMISSIONS BY SECTOR AND SOURCE



Stationary sources dominate, accounting for 75% of total emissions.



**STATIONARY SECTOR**

- Commercial, industrial and large residential buildings, including high rise offices, hospitals, universities and research buildings, manufacturing, and construction
- Small residential buildings.
- Energy generation supplied to the grid.
- Fugitive emissions from oil and natural gas systems.

Buildings over 35,000 square feet report their energy and water usage annually. The data is available at:

<https://data.boston.gov/dataset/building-energy-reporting-and-disclosure-ordinance>

Buildings represent the greatest challenges and opportunities for reducing emissions in Boston. In Boston, energy use in stationary sources dominates, accounting for 75% of total emissions (4.8 MtCO<sub>2</sub>e). Within the stationary sector, commercial, industrial, and large residential buildings generated 72% of emissions (3.5 MtCO<sub>2</sub>e) with small residential buildings accounting for 28% (1.3 MtCO<sub>2</sub>e). Fugitive gas emissions for all sectors account for less than 1% (31 thousand tCO<sub>2</sub>e) of emissions. Emissions in the building sector stem from the use of electricity (47%), natural gas (41%), fuel oil (10%), and steam (2%).

**TRANSPORTATION**

Emissions from transportation comprise 24% of the inventory (1.6 MtCO<sub>2</sub>e). This is lower than the statewide or national shares because of Boston’s density and robust public transportation system. More than half of Bostonians get to work via a mode other than a car ([GoBoston2030](#))<sup>5</sup>.

The inventory captures the emissions from the estimated Vehicle Miles Traveled (VMT) inside the city, plus public transportation vehicles, and off-road vehicles used at the airport and wastewater treatment plant. Primary sources of energy use in transportation include gasoline (75%), diesel (20%), electricity (4%), CNG and propane combined (<2%).

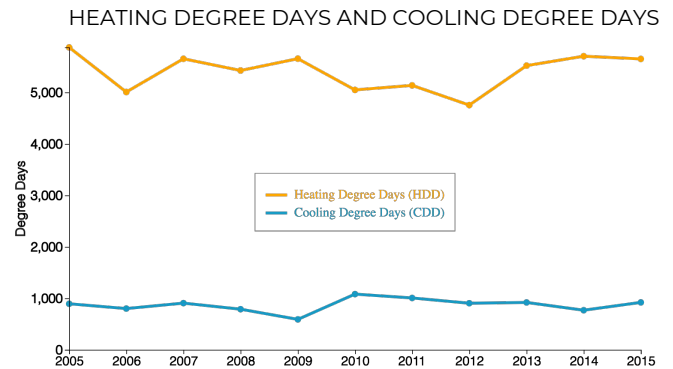
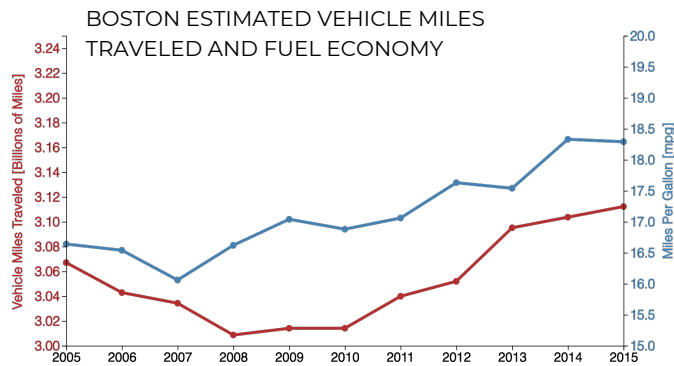
**WASTE**

GHGs reported in the waste sector refer to emissions from wastewater treatment only and account for less than 1% of total emissions (18 thousand tCO<sub>2</sub>e). The majority of Boston’s solid waste is sent to Waste To Energy (WTE) incineration plants that feed the electricity grid, so the emissions are accounted for in the emissions factor calculated by the regional electricity system operator, [ISO-NE](#). Tonnage of waste is tracked. Boston has a [Zero-Waste Initiative](#)<sup>6</sup> and the exclusion of emissions from solid waste in our GHG Inventory does not affect the City’s commitment to waste reduction.

**FACTORS DRIVING THE CHANGES**

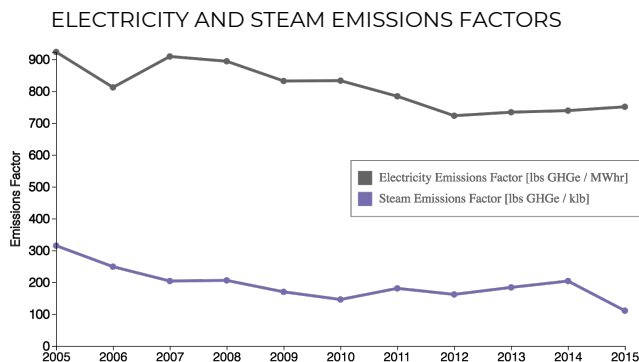
In 2015, the community’s GHG emissions rose 2% (126 thousand tCO<sub>2</sub>e) from the previous year and 3.6% (222 thousand tCO<sub>2</sub>e) from 2013. These increases reflect that:

- Electricity emissions factor increased. Electricity supplied by the regional grid operator, ISO-NE was generated using more natural gas (5% increase) and less nuclear power (4% decrease)<sup>7, 8</sup>.
- Emissions factors for steam dipped for two reasons. Natural gas replaced oil as an energy source. The big drop from 2014 to 2015 reflects the steam utility’s, Veolia’s, addition to their network of the Kendall Square Cogeneration plant, which recycles waste heat from electric generation for steam heating, heating water, or powering chillers<sup>9</sup>.
- Bostonians consumed more heating fuels. 2014 and 2015 were cold winters with 5704 and 5651 heating-degree days (HDD) respectively. By comparison, 2012 was a particularly warm year with only 4754 HDD<sup>10</sup>.
- Estimated vehicle miles traveled increased.

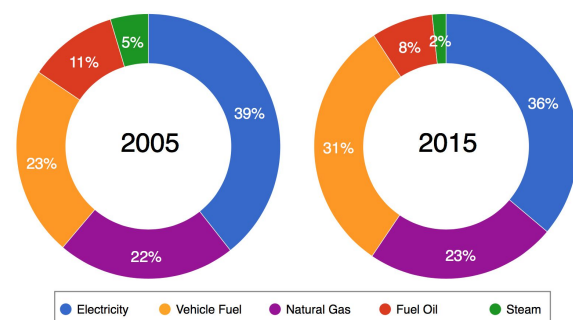


Despite the 2014-2015 increase, GHG emissions from 2005 to 2015 have declined by about 13%. Nearly 80% of reductions were the result of improvements in the electricity and steam emissions factors and reductions in consumption of fuel oil. Much of this can be attributed to fuel-switching from oil and coal to natural gas, by power plants and residents heating their homes. Steam emissions reductions resulted from fuel-switching from oil to natural gas as well as the addition of the steam utility’s [co-generation plant](#), which began serving Boston in 2014. Improvements in vehicle fuel economy have also made a large contribution to overall reductions.

The energy-efficiency efforts of the [Renew Boston](#) program, Boston’s utilities, and many businesses, institutions, and residents have made significant contributions that have offset much of Boston’s recent growth.



EMISSIONS BY SOURCE IN 2005 AND 2015



**UNCERTAINTY**

The inventory uses a combination of measured data, projections, models, and where data is scarce, best estimates. All of these sources have some level of uncertainty, most of which have not been quantified. Furthermore, the inventory is frequently revised as new and better data become available, models are improved, new methodology is developed, and international standards evolve.<sup>11</sup> Trends are likely more reliable than absolute numbers.

**CARBON FREE BOSTON**

In December 2017 Mayor Martin J. Walsh announced the launch of [Carbon Free Boston](#) (CFB). The initiative's first step is to analyze the GHG emissions reductions, costs and benefits of policies, and technologies that could enable Boston to reach our goal of carbon neutrality by 2050. It will also include an in-depth reanalysis of the city's emissions inventory, which may uncover new data sources and provide alternative methodologies for accounting for our GHG emissions. *Carbon Free Boston* will inform next year's update of the City's [Climate Action Plan](#).

# LOCAL GOVERNMENT OPERATIONS

## BACKGROUND

The Local Government Operations (LGO) inventory calculates all greenhouse gas emissions generated by municipal operations in the City of Boston. This includes the burning of fuels in the city’s facilities, vehicles, and other equipment, and the energy used in municipal buildings, vehicles, parks, street lights, and traffic signals. The LGO inventory is based on the ICLEI<sup>12</sup> greenhouse gas reporting protocol for local government operations. Under the protocol, emissions that are not under the operational control of the city government or involve leased properties are excluded. Emissions from the Boston Housing Authority, the Massachusetts Water Resources Authority (MWRA), and the Boston Planning and Development Agency (BPDA) are not included in the inventory. Those from the Boston Public Health Commission (BPHC) and the Boston Water and Sewer Commission (BWSC) are.

While the timeframe for the citywide inventory is the calendar year, the LGO inventory is conducted on the fiscal year, July-June. Because the data for these inventories is collected using separate protocols and on different timescales, the LGO should be considered to be largely overlapping but not completely contained within the Citywide inventory.

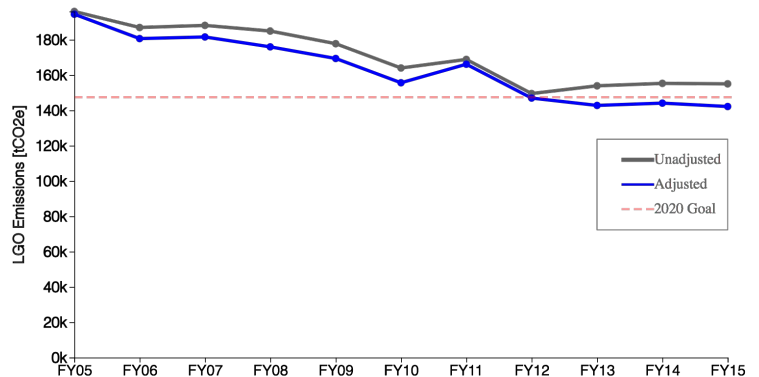
## OVERALL EMISSIONS

Municipal emissions saw a modest uptick from FY13 to FY14, primarily due to increased natural gas consumption as a result of cold winters in 2014 and 2015. However, FY15 emissions are down nearly 21% from 2005, before including adjustments for the purchase of renewable energy credits. Adjusting for the City of Boston’s purchases of Green-E Certified Renewable Energy Certificates (RECs) equal to approximately one fourth of our total electricity consumption, emissions in FY15 are down nearly 27% from 2005 levels. This means the City of Boston met our municipal 2020 goal of reducing GHG emissions 25% below 2005 levels 5 years ahead of schedule.

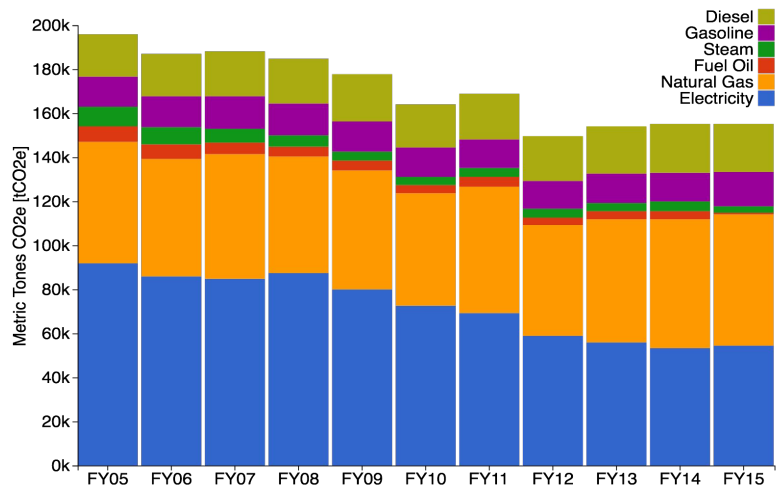
## EMISSIONS BY ENERGY SOURCE

Boston’s LGO emissions are dominated by building energy consumption. Electricity and gas consumption by buildings each make up about one third of total GHG emissions. Transportation fuels, diesel and gasoline, together make up one fourth of total municipal GHG emissions.

LOCAL GOVERNMENT OPERATIONS EMISSIONS

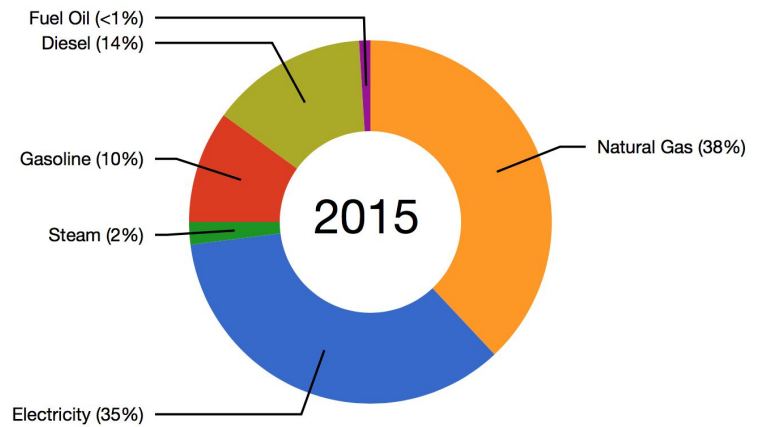


LGO EMISSIONS BY SOURCE TYPE (UNADJUSTED)



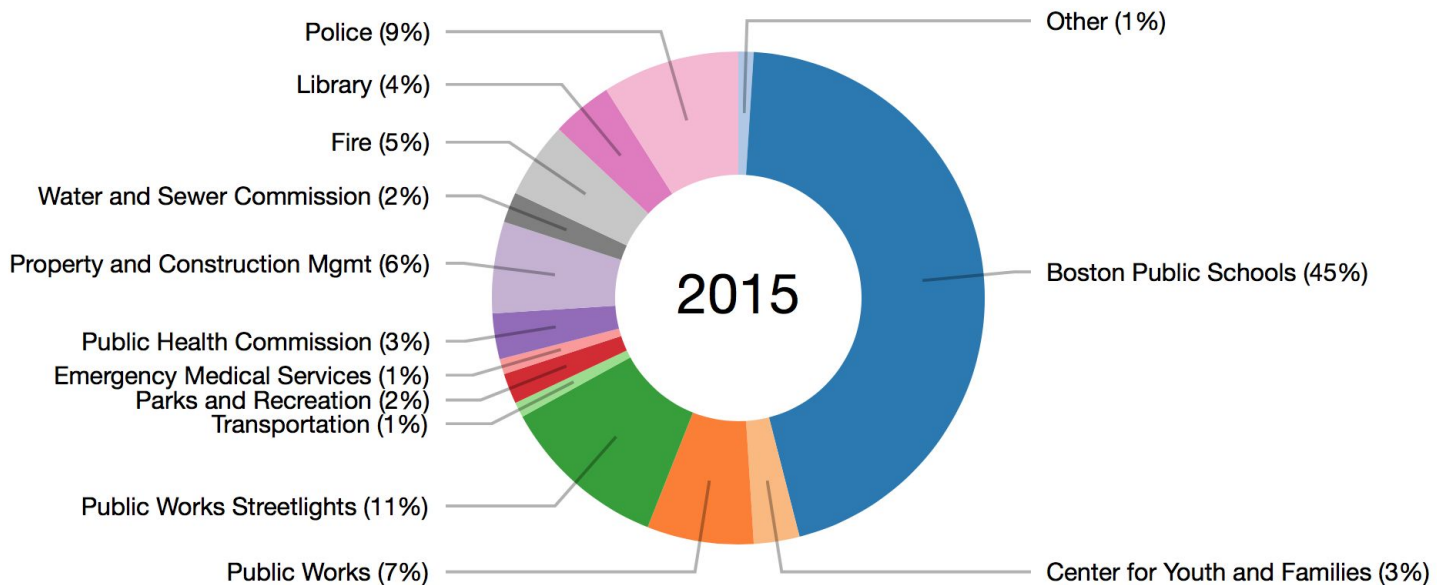


The closure of Boston Public Health Commission’s Long Island Campus resulted in a dramatic reduction of heating fuel oil; the island used to account for three quarters of all municipal heating oil consumption. While relatively negligible in the scheme of overall emissions, an additional 75,000 gallons of diesel were needed to melt excess snow cleared from streets during the series of blizzards over the winter of 2014-2015. This unexpected fuel consumption represents nearly 0.5% of total emissions in FY15.



**DEPARTMENTAL EMISSIONS**

As the department with the largest building portfolio, and the second largest vehicle inventory (after Boston Police Department), the Boston Public School Department represents the largest source of municipal emissions. BPS owns and operates approximately 12 million of the city’s 16 million square feet of building space across the roughly 127 school buildings in the district<sup>13</sup>. These buildings represent one third of municipal electricity consumption and two thirds of municipal gas consumption. The BPS bus fleet of over 750 vehicles uses two thirds of the diesel fuel consumed by city government. In recent years, BPS has been cleaning up the bus fleet by converting some of the oldest, dirtiest diesel buses to cleaner-burning propane engines. These vehicles provide a substantial reduction in local air pollution and roughly a 15% reduction in GHG emissions per bus per year. The next largest source of GHG emissions from municipal operations is the Public Works Department’s street lights. The 66,000 electric street lights and the 2,800 natural gas street lights found in Boston’s historic districts account for over 10% of total municipal GHG emissions. Street lighting used to make up a much larger share of Boston’s municipal GHG profile; however, aggressive conversions of electric street lights to LEDs dating back to 2010 have cut emissions from street lights in half. While gas lamps comprise just 4% of total street light fixtures, they produce 31% of GHG emissions from street lights.



**FACTORS DRIVING THE CHANGES**

- Natural gas use has increased and heating oil use has decreased over the long term (especially in the last two fiscal years) as the city converted some older schools from oil to gas, and opened new buildings that use natural gas for heat and hot water.
- In the last two fiscal years, Boston has seen an additional dramatic reduction in fuel oil use resulting from the closure of the Boston Public Health Commission's Long Island facility, which relied primarily on fuel oil as a heating source.
- Electricity use has decreased over the long term, primarily driven by the near complete conversion of Boston's 66,000 electric streetlights to more efficient LED fixtures. Boston has also invested in building energy efficiency measures on a project-by-project basis, and plans to engage in deeper energy efficiency retrofits as part of the newly launched Renew Boston Trust energy savings performance contract efforts.
- Steam use has decreased over the long term due to the reduction in steam use at City Hall, and the conversion of the West End Branch library from steam to gas. There was also a temporary reduction of usage in 2015 at Copley Library during construction and renovations. As of FY16, we expect it to be back to former levels of use.
- Electricity and steam emissions factors have decreased as described in the community inventory (p4).

## APPENDIX - INVENTORY METHODOLOGY

### COMMUNITY INVENTORY PROTOCOL

In 2015, Mayor Walsh signed on to what is now known as the Global Covenant of Mayors ([GCoM](#)), which required the city to follow the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories ([GPC](#)). [ICLEI Local Governments for Sustainability](#), whose guidance the city already followed, was a co-developer of the GPC, so the differences were not major. The two main changes were in the categories in which the data is collated, and in two new categories of emissions collected. The GPC requires the ethanol content of gasoline to be reported as a separate biogenic source of emissions, and for an accounting of fugitive gas emissions from the natural gas supply system.

Boston's GHG inventories are reported in CO<sub>2</sub> equivalents (or CO<sub>2</sub>e) which is a universal unit of measurement that accounts for the global warming potential (GWP) of different greenhouse gases. Boston's GHG inventory includes carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), and uses Global Warming Potentials (GWPs) from the latest version of the International Panel on Climate Change (IPCC) Guidelines (currently 5AR). The formula used to determine the CO<sub>2</sub>e from a given energy use is Activity Data x Emissions Factor<sup>1+2+3</sup> = GHG Emissions from the activity.

Boston currently is choosing to report at the GPC BASIC level<sup>2</sup>, which covers scope 1 and scope 2 emissions from stationary and transportation sources, as well as scope 1 and scope 3 emissions from waste.

**Scope 1:** GHG emissions from sources located within the city boundary

**Scope 2:** GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam, and cooling within the city boundary

**Scope 3:** All other emissions that occur outside the city boundary as a result of activities taking place within the city boundary

*Details of the inventory accounting methodology prior to the 2013 reporting year are found in "[City of Boston Community Greenhouse Gas Inventory 2005-2013](#)"<sup>14</sup>. Post 2013, accounting follows the GPC Protocols, which can be found in "[Global Protocol for Community-Scale Greenhouse Gas Emission Inventories \(GPC\)](#)"<sup>2</sup>. Below we note adjustments to prior years based on new or revised data and highlight changes in accounting between GPC and the prior protocol.*

### CHANGES WITH GPC ADOPTION

Boston's adoption of the GPC required a number of changes in our inventory:

- Inclusion of rail, ferry, and off-road transportation energy sources.
- Inclusion of emissions from the aerobic and anaerobic treatment of wastewater, from the water treatment plant inside the city boundary.
- Estimation of fugitive gas from the natural gas supply system.
- Ethanol, estimated at 10% of gasoline sold in the region, is counted as biogenic emissions, and therefore not included in the total GHG emissions reported.
- Emissions factors were updated and CH<sub>4</sub> and N<sub>2</sub>O were included consistently.
- Accounting for the wastewater treatment plant located inside Boston was modified (see data revisions section below).

Data from prior years (2005 - 2014) were updated to reflect the changes in methodology. Where the actual data could not be collected, data from the nearest available year was used, scaled by the change in population between the two years. The recalculation resulted in a less than 1% change in each year's inventory.

## DATA REVISIONS

- We discovered a few areas where we received data from dual sources that resulted in a double count of energy use. Adjustments have been made for all discovered sources and applied back to the baseline year.
- Accounting for the Deer Island Wastewater Treatment Plant and other Massachusetts Water Resources Authority (MWRA) buildings inside of Boston has been adjusted. Historically we attributed a percentage of the MWRA system-wide energy use to Boston, based on Boston's pro rata share of wastewater treated. After reevaluation of the GPC guidelines, we decided that a better method was to attribute all the energy used at Deer Island and any other facilities inside Boston to Boston at 100%, and apply a proportion reflecting just Boston's contribution to the wastewater effluent and processing emissions. Other emissions from treated wastewater are not included because it is released far into the harbor, outside of Boston.
- The Boston Metropolitan Planning Organization's Central Transportation Planning Staff ([CTPS](#))<sup>15</sup> released an updated model that estimates vehicle miles traveled (VMT). This model estimates VMTs in a baseline year, 2012, and a future year (2020). They then linearly interpolate between the two years to determine annual VMTs.

## MUNICIPAL INVENTORY METHODOLOGY

The Local Government Operations inventory methodology for calculating GHG emissions is based on the ICLEI<sup>11</sup> greenhouse gas reporting protocol for local government operations, developed by ICLEI and the National Association of Clean Air Agencies. The protocol categorizes emissions as direct (Scope 1) or indirect (Scope 2). Direct emissions come from the burning of natural gas, fuel oil, gasoline, diesel fuel, and other fuels in the City's facilities, vehicles, and other equipment. Indirect emissions come from the burning of fuels in facilities owned and operated by others to produce electricity, and steam that the City uses. Emissions that are not under the operational control of the City government, or involve leased properties, are excluded. Emissions from the Boston Housing Authority, the Massachusetts Water Resources Authority (MWRA), and the Boston Planning and Development Agency (BPDA) are not included in the inventory. Those from the Boston Public Health Commission (BPHC), and the Boston Water and Sewer Commission (BWSC) are.

In 2013 the City invested in an Enterprise Energy Management System (EEMS) and an Energy Manager to track and report local government energy consumption, cost, and GHG emissions. Prior years' reporting relied on annual data collection from numerous stakeholders in the auditing, budget, and purchasing offices. This manual process sometimes led to inconsistent data collection from year to year. Now the process is almost entirely automated, and with complete invoice data for over 7 calendar years entered, the City can track progress towards energy and GHG reduction goals on a monthly basis. By tracking this data more closely, the City is able to identify which departments, buildings or assets are contributing most to our overall portfolio, and in the process, has identified errors in utility bills worth over \$1.2M in credits back to the City.

## REFERENCES

- [1] State of the City 2017. November 14, 2017, <https://www.boston.gov/departments/mayors-office/state-city>
- [2] Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). November 14, 2017, [http://www.ghgprotocol.org/sites/default/files/ghgp/standards/GHGP\\_GPC\\_0.pdf](http://www.ghgprotocol.org/sites/default/files/ghgp/standards/GHGP_GPC_0.pdf)
- [3] U.S. Census Bureau. November 14, 2017, <https://www.census.gov/> [with adjustments from Boston At a Glance - 2017. November 20, 2017, <https://www.bostonplans.org/getattachment/0d0f7912-e704-498d-999c-318cd9abdb68>]
- [4] Boston's Economy Report 2017. November 20, 2017, <http://www.bostonplans.org/getattachment/d835ad4c-e8a9-4f17-b342-468f02301c58>
- [5] Go Boston 2030. November 14, 2017, <https://www.boston.gov/departments/transportation/go-boston-2030>
- [6] Zero Waste. November 14, 2017, [http://www.greenovateboston.org/zero\\_waste\\_action](http://www.greenovateboston.org/zero_waste_action)
- [7] 2014 ISO New England Electric Generator Air Emissions Report. November 14, 2017, [https://www.iso-ne.com/static-assets/documents/2016/01/2014\\_emissions\\_report.pdf](https://www.iso-ne.com/static-assets/documents/2016/01/2014_emissions_report.pdf)
- [8] Final 2015 ISO New England Electric Generator Air Emissions Report. November 14, 2017, [https://www.iso-ne.com/static-assets/documents/2017/01/2015\\_emissions\\_report.pdf](https://www.iso-ne.com/static-assets/documents/2017/01/2015_emissions_report.pdf)
- [9] Kendall Cogeneration Station. November 14, 2017, <http://www.veolianorthamerica.com/sites/g/files/dvc596/f/assets/documents/2017/08/Veolia-Kendall-Tour-Brochure-and-CHP-graphics-2016.pdf>
- [10] NOAA Local Climatological Data Publication. November 14, 2017, <https://www.ncdc.noaa.gov/IPS/lcd/lcd.html>
- [11] 1.5°C: Aligning New York City with the Paris Climate Agreement. November 14, 2017, <https://onenyc.cityofnewyork.us/wp-content/uploads/2017/10/1point5-AligningNYCwithParisAgrmtFORWEB.pdf>
- [12] ICLEI Local Government Operations Protocol. November 14, 2017, [https://s3.amazonaws.com/icleiusaresources/lgo\\_protocol\\_v1\\_1\\_2010-05-03.pdf](https://s3.amazonaws.com/icleiusaresources/lgo_protocol_v1_1_2010-05-03.pdf)
- [13] Build BPS Facilities Master Plan. November 14, 2017, [http://buildbps.org/data/misc/BuildBPS\\_Executive%20Summary.pdf](http://buildbps.org/data/misc/BuildBPS_Executive%20Summary.pdf)
- [14] City of Boston Community Greenhouse Gas Inventory 2005-2013. November 14, 2017, [https://www.cityofboston.gov/images\\_documents/Community%20GHG%20Inventory%202013\\_tcm3-49977.pdf](https://www.cityofboston.gov/images_documents/Community%20GHG%20Inventory%202013_tcm3-49977.pdf)
- [15] Central Transportation Planning Staff (CTPS). November 20, 2017, <http://www.ctps.org/>



## **ACKNOWLEDGEMENTS**

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Mass Energy Consumers Alliance  
Massachusetts Port Authority (Massport)  
Massachusetts Water Resources Authority (MWRA)  
National Grid  
Veolia

### **DESIGN CREDITS**

Cover photo provided by the City of Boston  
All graphics produced using D3.js (<https://d3js.org/>)

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Local Government Operations Inventory: Adam Jacobs, Energy Manager [adam.jacobs@boston.gov](mailto:adam.jacobs@boston.gov)