



CITY OF BOSTON GREENHOUSE GAS EMISSIONS INVENTORY 2005-2017

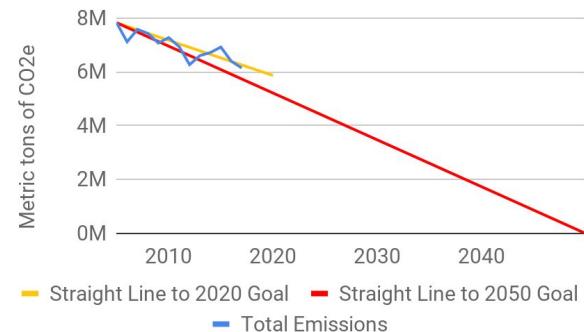
OVERVIEW

In 2017, the Boston community emitted 6.1 million metric tons of greenhouse gases (GHGs) from energy use in buildings and other facilities, and from transportation. This is an almost 4% decrease from 2016, when Boston emitted 6.4 million metric tons according to revised estimates.¹ Overall, Boston's 2017 emissions represent a 21% decrease from 2005. Major contributors to the decrease were an increasingly cleaner electric grid and reductions in natural gas and heating oil use.

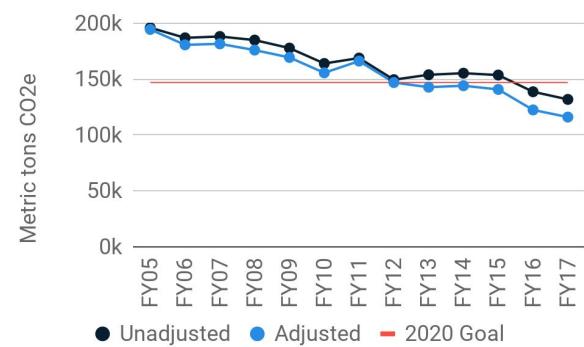
Boston Local Government Operations emitted 132 thousand metric tons of GHGs, a 41% reduction from 2005, including renewable energy credits (RECs), and a 33% reduction without RECs. In 2015, the City of Boston already met the 2020 goal of reducing municipal GHGs by 25% below 2005 levels, five years ahead of schedule.

GHG inventory data are available at:
<https://data.boston.gov/dataset/greenhouse-gas-emissions>

BOSTON COMMUNITY GHG EMISSIONS



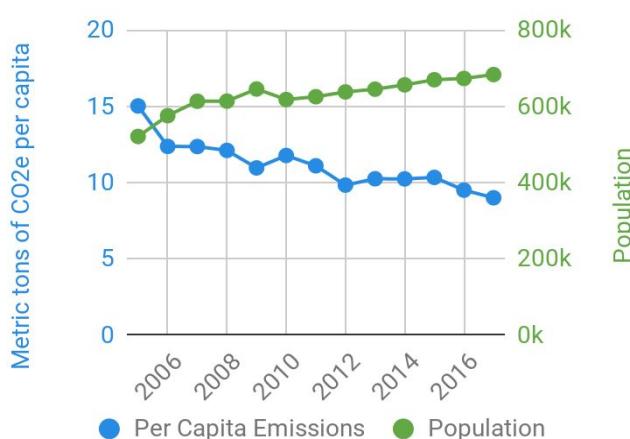
LOCAL GOVERNMENT OPERATION EMISSIONS



ECONOMIC & POPULATION GROWTH

The reduction in Boston's emissions has occurred at the same time that the population and the number of jobs in Boston have increased. Since 2005, the Boston community has grown from 520 thousand to more than 680 thousand residents in 2017,² and Boston's economic growth, as measured by Gross City Product (GCP), has increased from 91 billion dollars to 129 billion.³ Emissions per Boston resident over the same time period have decreased 40%, from 15.0 metric tons per year, to 9.0 metric tons. Emissions per million dollars of GCP have decreased 45%, from 86 metric tons per million dollars to 48 metric tons per million dollars.

BOSTON EMISSIONS PER CAPITA



BOSTON EMISSIONS PER GROSS CITY PRODUCT



BACKGROUND

In his 2017 State of the City address, Mayor Martin J. Walsh announced the City's goal of carbon neutrality by 2050.⁴ This commitment underlies the City's Climate Action Plan, which is being updated for the third time.⁵ To measure progress, Boston follows the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).⁶ The baseline year is 2005, the first year in which consistent and reliable data was collected. Boston has an interim goal to reduce citywide emissions by 25% by 2020.

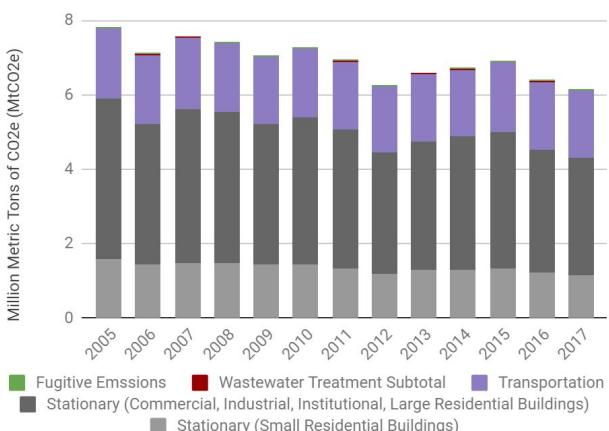
The annual GHG inventory is based on a combination of direct data and estimates for data that cannot be obtained directly (see box below). Data sources include City records, utility company reports, and information from state and federal agencies. Reporting is separated into community-wide and local 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.

WHAT'S INCLUDED?	 Energy used by buildings and other stationary sources; fugitive emissions from natural gas distribution within Boston limits	 On-road and some off-road transportation, and public transportation trips within city limits.	 Wastewater treatment within city limits.
WHAT'S NOT?	Emissions generated outside the city boundary to produce goods 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.		

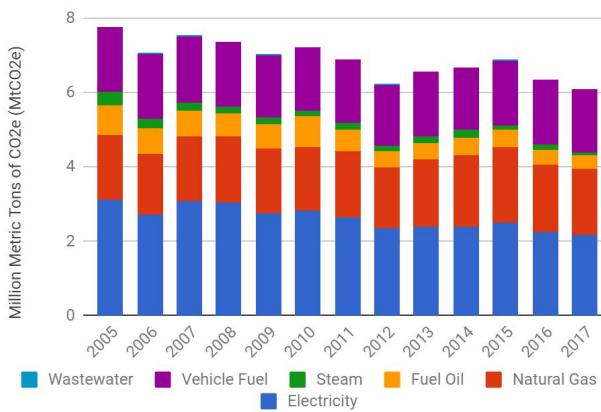
EMISSIONS BY SECTOR & SOURCE

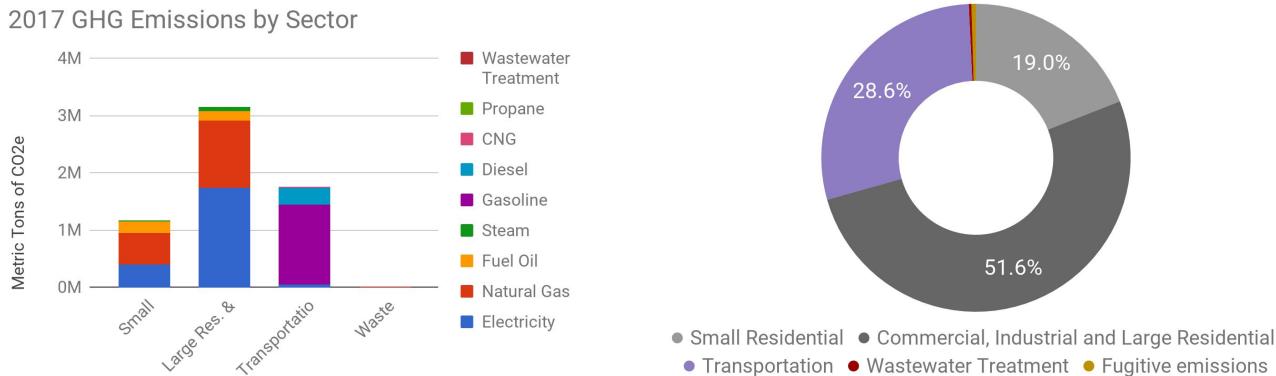
This report contains details of GHG emissions from 2005 to 2017 by energy source and sector. GHG levels reflect both the quantity of energy used and the source of that energy.

BOSTON EMISSIONS BY SECTOR



BOSTON EMISSIONS BY SOURCE





STATIONARY SECTOR

The community inventory tracks stationary sector emissions from:

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

In Boston, energy use in stationary sources dominates, accounting for 70% of total emissions (4.3 MtCO₂e). Commercial, industrial, and large residential buildings generated 51% of emissions (3.1 MtCO₂e), while small residential buildings accounted for 19% of emissions (1.2 MtCO₂e). Fugitive gas emissions for all sectors account for less than 1% (29 thousand tCO₂e) of emissions. Emissions in the building sector stem from the use of electricity (50%), natural gas (40%), fuel oil (8%), and steam (2%).

All buildings over 35,000 square feet publicly report their energy and water usage annually. Data is available at:
<https://data.boston.gov/dataset/building-energy-reporting-and-disclosure-ordinance>

TRANSPORTATION

Emissions from transportation comprise 29% of the inventory (1.8 MtCO₂e). This is lower than transportation's share of statewide or national emissions 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.⁷

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 in transportation include gasoline (76%), diesel (20%), natural gas (2%), electricity (2%), biodiesel and propane combined (<1%).

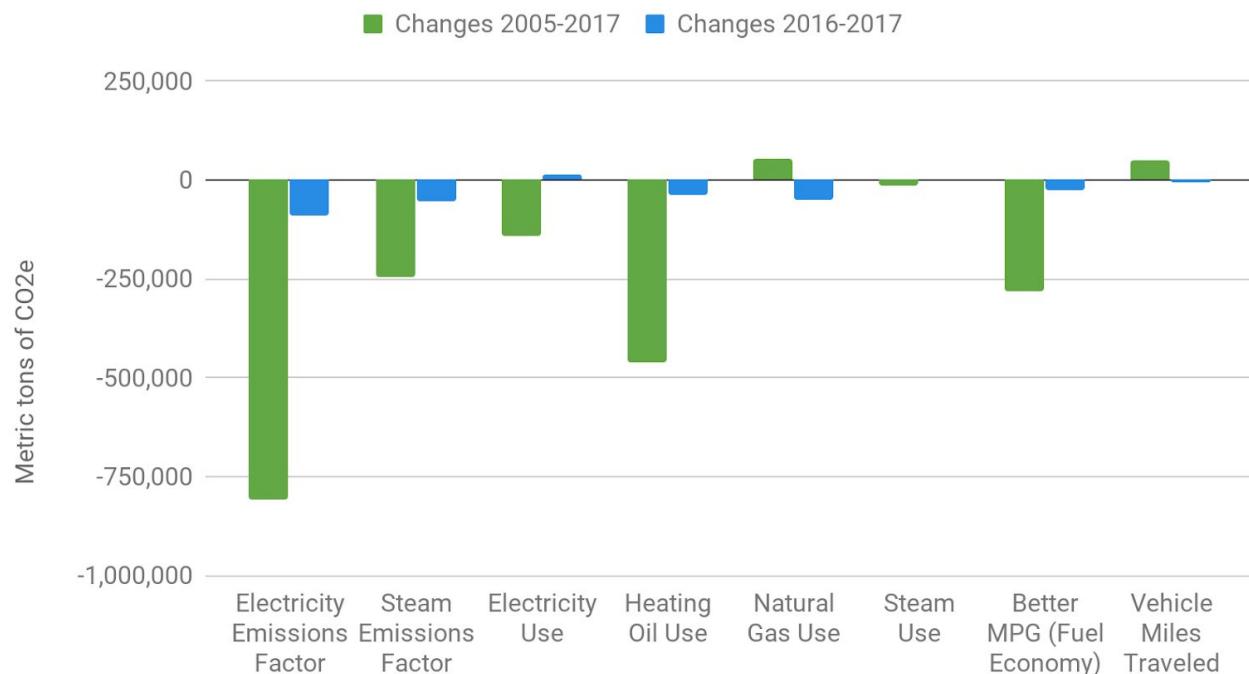
WASTE

GHGs reported in the waste sector refer to emissions from wastewater treatment only and account for less than 1% of total emissions (17 thousand tCO₂e). All, or almost all, of Boston's solid waste is sent to Waste-To-Energy (WTE) incineration plants that feed the electricity grid, so emissions are counted as part of regional electricity generation within this inventory. This means solid waste emissions are embedded in the emissions from electricity used in buildings and transportation.

The Carbon Free Boston analysis estimated that Boston's waste sector accounted 393 thousand tons of direct carbon emissions in 2017, if the WTE emissions are broken out from the electricity emissions factor.⁸ The Zero Waste Boston initiative has issued strategies to reduce, reuse, recycle and compost at least 80 to 90 percent of Boston's solid waste.⁹ The Carbon Free Boston analysis determined that a 90 percent diversion rate would reduce waste emissions by 78% relative to 2017 emissions, including the WTE emissions.

FACTORS DRIVING THE CHANGES

WHERE OUR CHANGES COME FROM



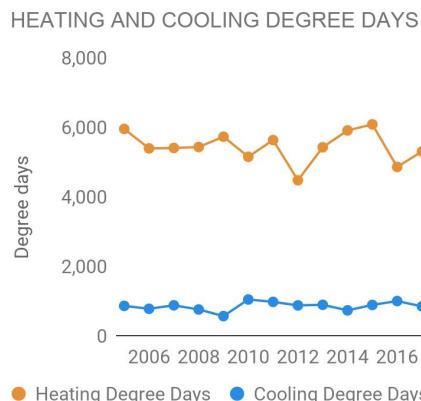
Short-term changes

In 2017, the community's GHG emissions decreased 4% (248 thousand tCO₂e) from the previous year. These decreases reflect that:

- Boston businesses and institutions consumed less natural gas, and Boston residents used less fuel oil, to heat buildings. The winter of 2017 was colder than that of 2016,¹⁰ but average natural gas prices were higher.¹¹
- Regional emissions per unit of electricity decreased by 3.9%. Electricity supplied by the regional grid operator, ISO-New England, was generated using more wind and hydropower (1% increase each), and less natural gas (1% decrease).^{12,13}

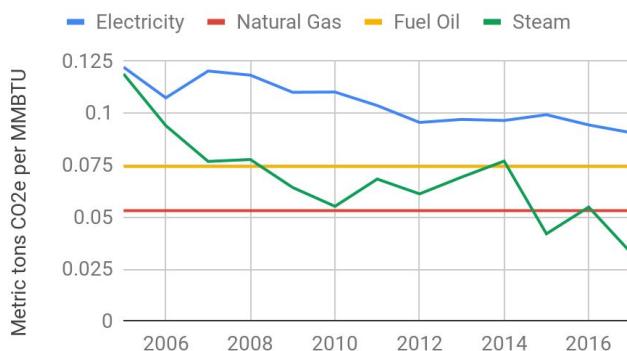
Long-term changes

Boston's GHG emissions from 2005 to 2017 have declined by more than 21%. 44% of GHG reductions are the result of state-level and regional action to clean the New England electric grid. As a result, the electricity

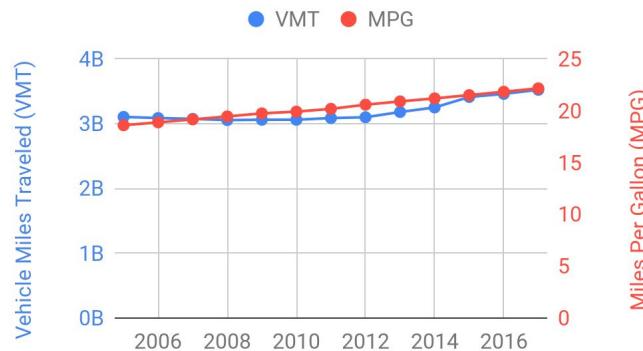


emissions factor has improved continuously over time, as electricity has been less carbon-intensive. Another 25% of GHG reductions may be attributed to reduced fuel oil use. This is because many households and businesses are switching from fuel oil to natural gas to heat their homes. Steam has become cleaner thanks to fuel-switching from oil to natural gas and the addition of the Kendall cogeneration plant in 2014. The average fuel economy of vehicles registered in Boston has also improved from 19.8 miles per gallon (mpg) in 2009 to 21.2 mpg in 2014 (most recent year for which Boston-specific data is available).¹⁴

GREENHOUSE GAS EMISSIONS FACTORS

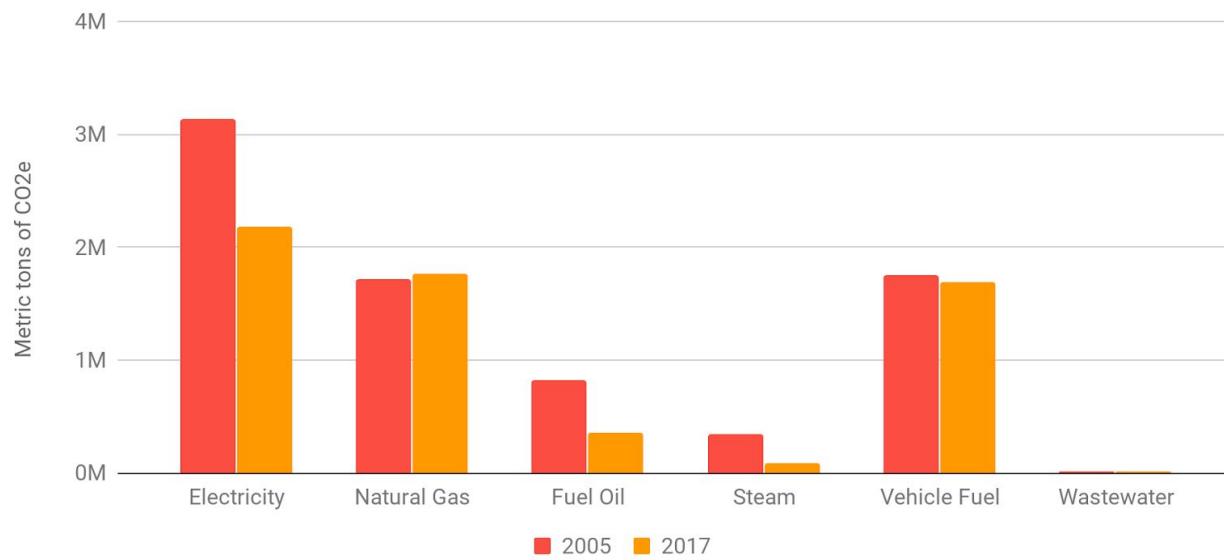


VEHICLE MILES TRAVELED AND FUEL ECONOMY



The energy-efficiency efforts of the Renew Boston program, Boston's utilities, local government and many businesses, institutions, and residents have offset much of Boston's recent growth.

EMISSIONS BY SOURCE IN 2005 AND 2017



UNCERTAINTY

The inventory employs 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.¹⁵ For these reasons, longer term trends are likely more reliable than absolute numbers or year-to-year changes.

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 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 included.

While the timeframe for the citywide inventory is the calendar year, the LGO inventory is conducted on the fiscal year (FY), 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

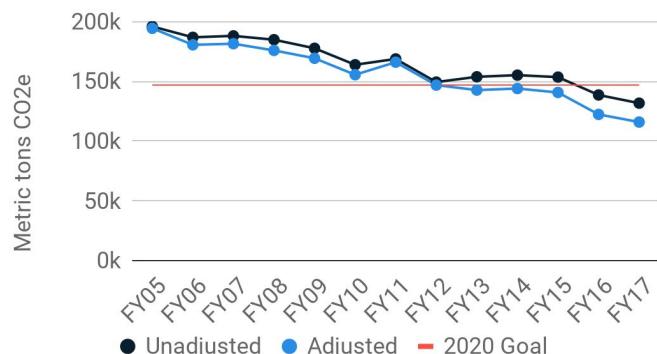
FY17 municipal emissions are down more than 33% from 2005, before including adjustments for the purchase of renewable energy credits.

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 FY17 are down nearly 41% from 2005 levels. The City of Boston met its municipal 2020 goal of a 25% reduction 5 years ahead of schedule.

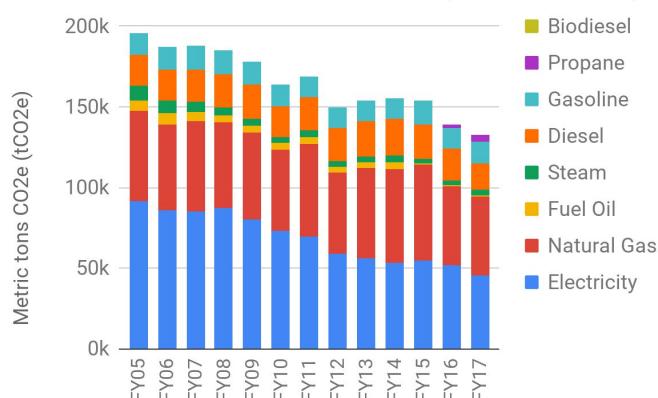
EMISSIONS BY ENERGY SOURCE

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. Similar to the community-wide inventory, Boston's municipal operations GHG inventory trends are driven by a number of external and

LOCAL GOVERNMENT OPERATION EMISSIONS



LGO EMISSIONS BY SOURCE TYPE (UNADJUSTED)



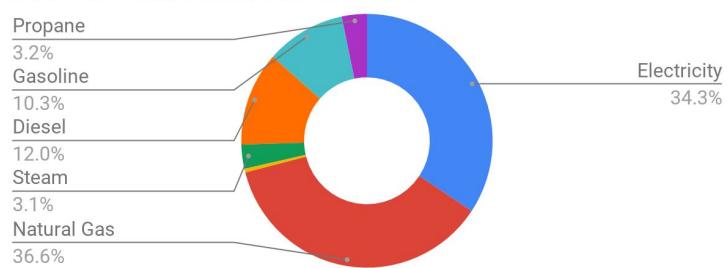
internal factors. Diesel consumption is continuing to decrease as Boston Public Schools switches its fleets from diesel- to propane-powered school buses. The continued downward trend in the regional electric grid emissions rate also contributed to reduced emissions.

DEPARTMENTAL EMISSIONS

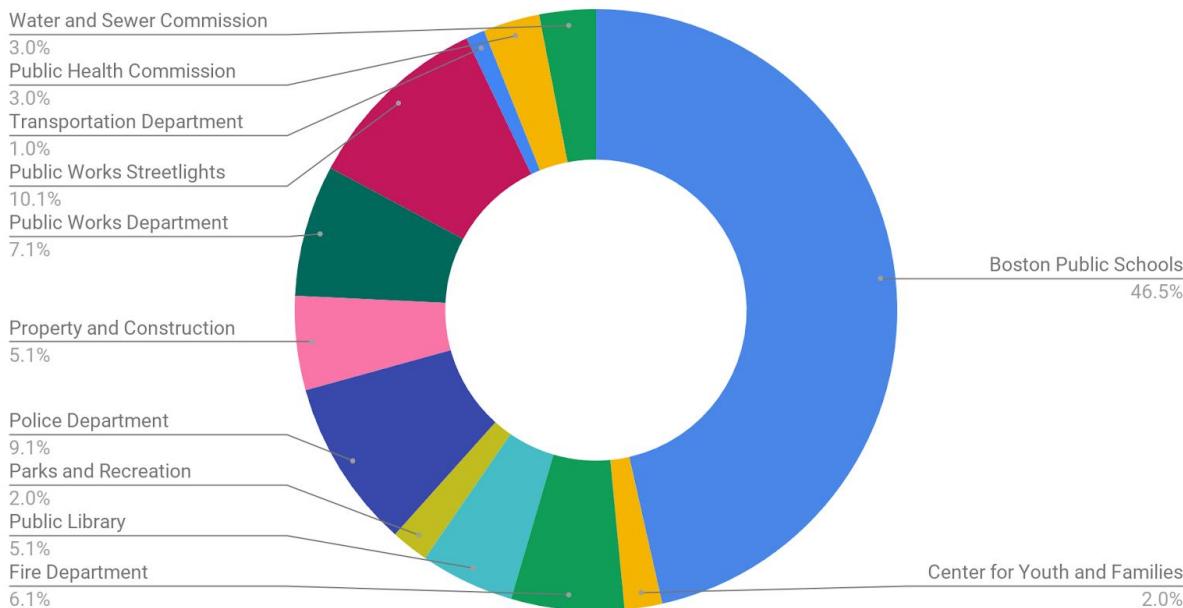
As the department with the largest building portfolio, and the second largest vehicle inventory (after Boston Police Department), Boston Public Schools (BPS) represent the largest source of municipal emissions. BPS owns and operates approximately 12 million of the City's 16 million square feet of building space across the roughly 127 school buildings in the district.¹⁶ These buildings represent approximately one third of municipal electricity consumption and two thirds of municipal gas consumption. The BPS Department of Transportation (DOT) fleet of over 700 vehicles uses nearly two thirds of all the diesel fuel consumed by City government. BPS has continued their replacement of the oldest, dirtiest diesel buses to lower emissions propane engines, which now comprise over one quarter of the fleet. Since BPS-DOT is on a roughly 10 year replacement cycle, these lower emissions vehicles will provide emissions reductions over the next decade.

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 9% 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.

FY17 LGO EMISSIONS BY SOURCE



FY2017 MUNICIPAL EMISSIONS BY DEPARTMENT





FACTORS DRIVING THE CHANGES

- The electricity emissions factor decreased as described in the community inventory.
- Natural gas and heating oil use has decreased over the long term (especially in recent fiscal years) as the City converted some older schools from oil to gas, and opened new, energy-efficient buildings that use natural gas for heat and hot water.
- Beginning in FY15, Boston has seen a 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 Renew Boston Trust.¹⁷
- 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.



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 CO₂ equivalents (or CO₂e) 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 (CO₂), methane (CH₄), and nitrous oxide (N₂O), 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 CO₂e from a given energy use is Activity Data x Emissions Factor¹⁺²⁺³ = GHG Emissions from the activity.

Boston currently is choosing to report at the GCP BASIC level, 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

Our full methodology may be found in “Boston Greenhouse Gas Inventory Methodology,” most recently updated for the 2016 inventory year.¹⁸

2016 DATA REVISIONS

- The Boston Metropolitan Planning Organization’s Central Transportation Planning Staff (CTPS) released an updated model that estimates vehicle miles traveled (VMT) for passenger vehicles, freight vehicles and other transportation modes. The new model estimates VMTs for passenger and freight vehicles for the year 2016. The Federal Highway Administration releases annual total daily VMT estimates for urbanized areas each year. We used the annual percent change for VMT in the Boston-Cambridge-Newton, MA-NH Metropolitan Statistical Area (MSA) to estimate VMTs for the 2005-2015 period.
- We have included newly available fuel use data from the Massachusetts Bay Transportation Authority, including service vehicle fuel use, gasoline for the paratransit program THE RIDE, and additional building fuel use, allowing for more granular reporting. This data was available for FY 2009 to FY 2016. We used passenger load, derived from MBTA Bluebook reports, to estimate fuel use for the FY 2005 to FY 2008 period.



- We included additional energy consumption data not related to air travel from Massport. Previous inventories included energy use data for ground support equipment and auxiliary power units. This has been expanded to include the Massport Shuttle Bus, the Massport Express Bus, the Massport Fire Rescue, agricultural equipment and Massport fleet vehicles.
- Previous iterations of the community inventory included vehicle fuel use for Boston Public School buses. The inventory has been updated to report municipal vehicle fleet fuel use across all municipal departments, including biodiesel and propane.

MUNICIPAL INVENTORY METHODOLOGY

The Local Government Operations inventory methodology for calculating GHG emissions is based on the ICLEI 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.

One notable correction in accounting methodology was a double-count identified in fleet fuels. When the City began reporting vehicle fuels based on delivery point in FY15, it did not account for the fact that Boston Public Health Commission (BPHC), and Emergency Medical Services (EMS) fueled their vehicles at the Department of Public Works (DPW) and Boston Fire Department (BFD) fueling stations. Fueling reports from BPHC and EMS were counted separately, even though said fuel use was already included in the DPW and BFD. This correction results in an approximately 141,000 gallon reduction between diesel and gasoline for the FY15 inventory. The correction is included in the new FY16 inventory, and all years FY05-FY14 are not affected by this correction.

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CITY OF BOSTON STAFF

Katherine Eshel
Adam Jacobs

ADDITIONAL CONTRIBUTORS

Boston Planning and Development Agency (BPDA)
Boston Public Schools (BPS)
Central Transportation Planning Staff (CTPS)
Massachusetts Bay Transportation Authority (MBTA)
Mass Energy Consumers Alliance
Massachusetts Port Authority (Massport)
Massachusetts Water Resources Authority (MWRA)
Eversource
National Grid
Veolia

DESIGN CREDITS

All graphics produced using Google Sheets.

Please direct comments or questions about the inventories to:
Katherine Eshel, Carbon Neutrality Program Manager, katherine.eshel@boston.gov