

B CITY OF BOSTON GREENHOUSE GAS EMISSIONS INVENTORY 2005-2021

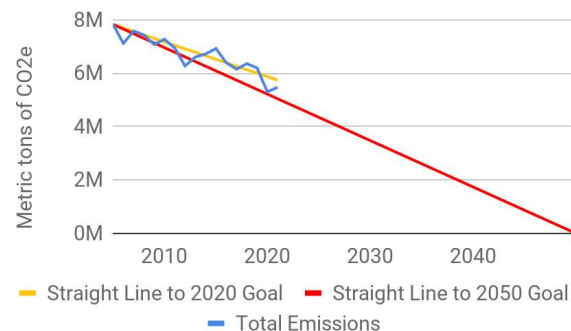
OVERVIEW

In 2021, the Boston community emitted 5.4 million metric tons of greenhouse gases (GHGs) from energy use in buildings and transportation. This is nearly a 13% decrease from 2019, when Boston emitted 6.2 million metric tons.¹ This decrease is exceptional and may largely be attributed to lower use of electricity and natural gas (also known as methane gas), and reduced vehicle travel during the COVID-19 pandemic. Citywide emissions are reported by calendar year.

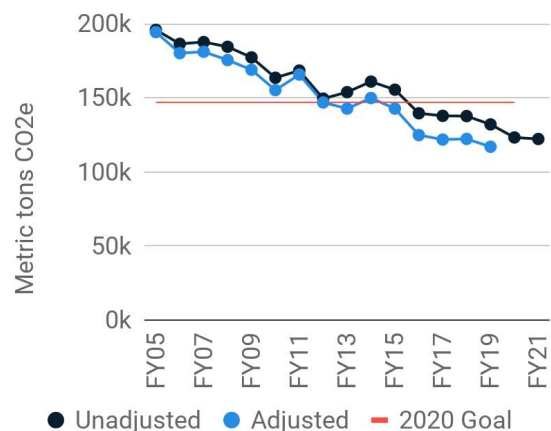
Boston achieved its 2020 climate goals of reducing emissions from both citywide activities and from local government operations by 25% below 2005 levels. The next citywide target is a 50% emissions reduction by 2030.

In Fiscal Year 2021, local government operations emitted 122 thousand metric tons of GHGs, a 38% reduction from 2005. The City of Boston met its 2020 goal of cutting municipal emissions 25% below 2005 levels in 2015, five years ahead of schedule. Local government operation emissions are reported by fiscal year.

COMMUNITY-WIDE EMISSIONS



LOCAL GOVERNMENT OPERATION EMISSIONS

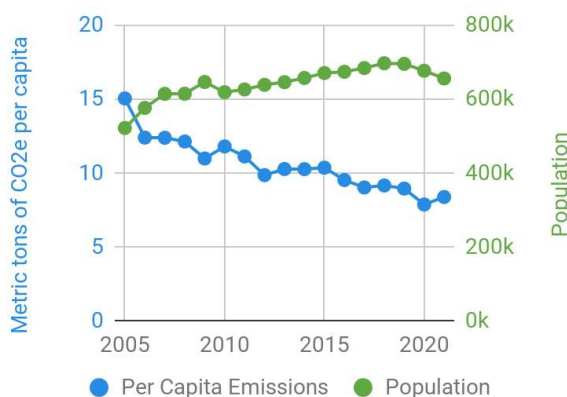


Greenhouse gas inventory datasets are available at: <https://data.boston.gov/dataset/greenhouse-gas-emissions>

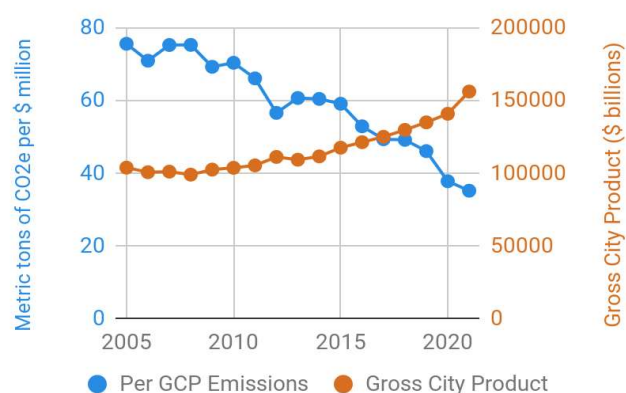
ECONOMIC & POPULATION GROWTH

The reduction in Boston's emissions has occurred at the same time that the population and the number of jobs in Boston have increased. The Boston community has grown from 521 thousand residents in 2005 to more than 654 thousand in 2021.² Emissions per resident over the same time period have decreased 44%, from 15 to 8 metric tons per year. Boston's economic growth, as measured by Gross City Product (GCP), has increased from 106 billion dollars to 156 billion.³ Emissions per million dollars of GCP have decreased 54%, from 76 to 35 metric tons per million dollars.

BOSTON EMISSIONS PER CAPITA



BOSTON EMISSIONS PER GROSS CITY PRODUCT



BACKGROUND

Mayor Michelle Wu has committed to achieving a Green New Deal for Boston, by tackling the climate crisis with strategies that address economic, social, and racial inequities. Eliminating greenhouse gas emissions that drive climate change is core to the vision, along with building resilience to a changing climate, and underpin Boston’s Climate Action Plan. To measure progress in reducing our greenhouse gas emissions, Boston follows the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). The baseline year is 2005, the first year in which consistent and reliable data was collected. Boston has achieved its interim goal of reducing citywide emissions by 25% by 2020, and has a goal to achieve a 50% reduction by 2030.

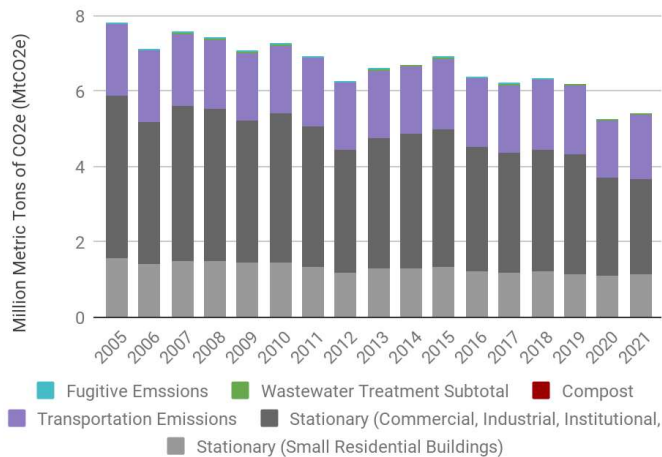
The annual GHG inventory is based on a combination of direct data and estimates for data that cannot be obtained directly (see box below). Data sources include City records, utility company reports, and information from state and federal agencies. Reporting is separated into community-wide and local 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 may be found online at <https://www.boston.gov/departments/environment/bostons-carbon-emissions>.

WHAT'S INCLUDED?		Energy used by buildings and other stationary sources; fugitive emissions from methane 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, or airplane emissions that cannot be attributed specifically to Boston). Boston will continue to evaluate the benefits and challenges of “consumption-based” emissions accounting as a complement to the current inventory methodology.					

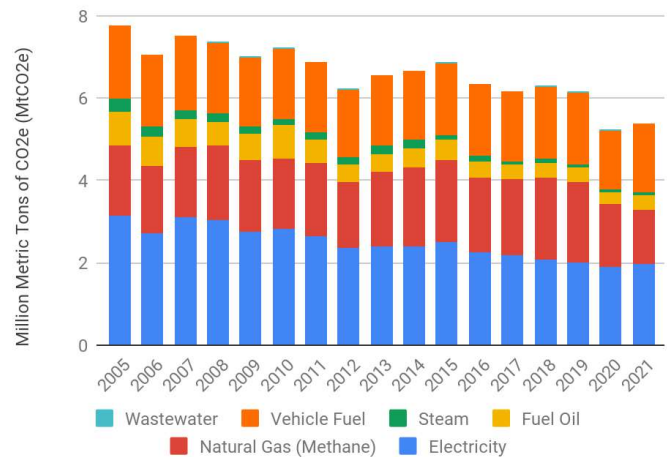
EMISSIONS BY SECTOR & SOURCE

This report contains details of GHG emissions from 2005 to 2020 by energy source and sector. GHG levels reflect both the quantity of energy used and the source of that energy.

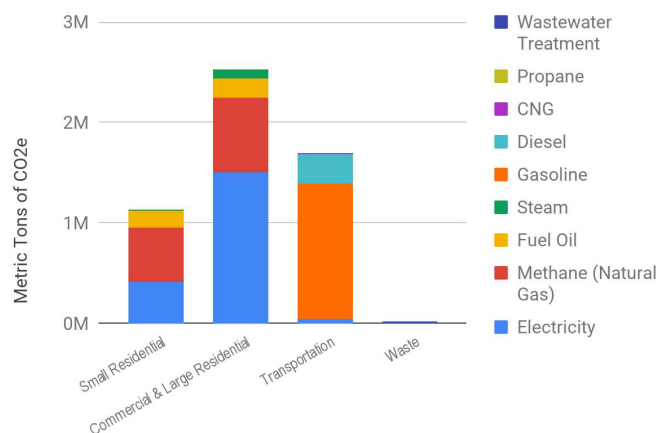
BOSTON EMISSIONS BY SECTOR



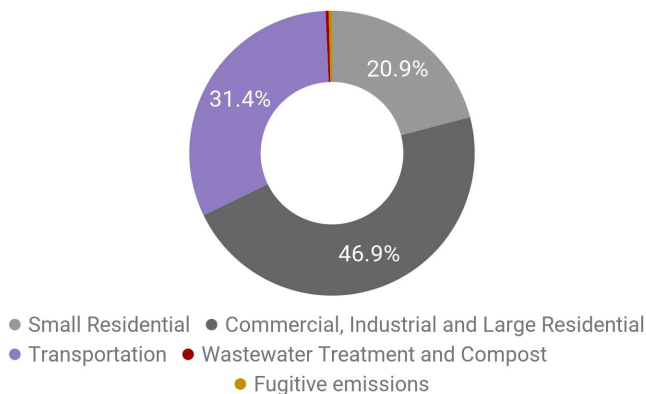
BOSTON EMISSIONS BY SOURCE



2021 GHG EMISSIONS BY SECTOR



2021 EMISSIONS BY SECTOR



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 (or methane gas) systems.

In Boston, energy use in stationary sources dominates, accounting for 68% of total emissions (3.6 MtCO₂e). Commercial, industrial, and large residential buildings generated 47% of emissions (2.5 MtCO₂e), while small residential buildings accounted for 21% of emissions (1.1 MtCO₂e). Fugitive gas emissions for all sectors account for less than 1% (20 thousand tCO₂e) of emissions. Emissions in the building sector stem from the use of electricity (52%), natural gas (or methane gas) (35%), fuel oil (10%), and steam (3%).

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

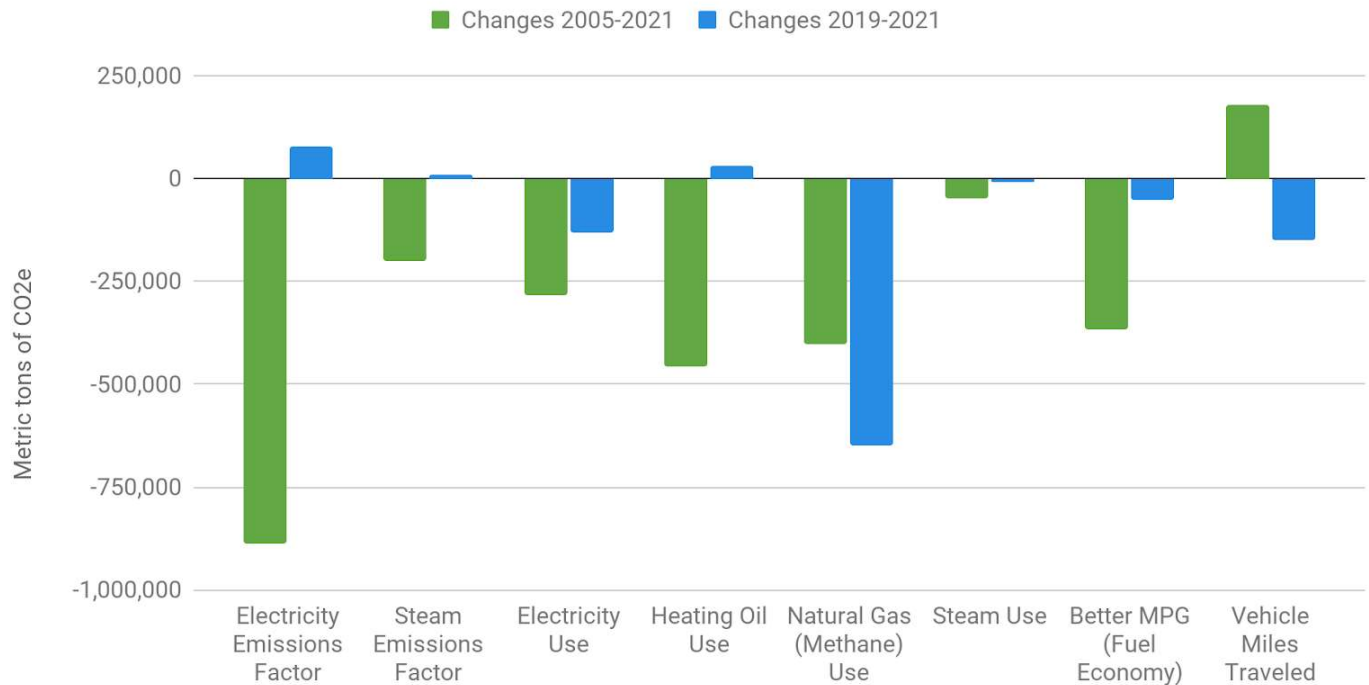
Emissions from transportation comprise 31% of the inventory (1.7 MtCO₂e). This is lower than transportation's share of statewide or national emissions because of Boston's density and public transportation system. More than half of Bostonians get to work via a mode other than a car.⁵ The inventory captures the emissions from the estimated Vehicle Miles Traveled (VMT) inside the City, plus public transportation and off-road vehicles used at the airport and wastewater treatment plant. Primary energy sources include gasoline (76%), diesel (20%), natural gas (or methane gas) (1%), electricity (2%), biodiesel and propane combined (<1%).

WASTE

GHGs reported in the waste sector refer to emissions from wastewater treatment and biological treatment of organic waste and account for less than 1% of total emissions (19 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.⁶ The Zero Waste Boston initiative has issued strategies to reduce, reuse, recycle and compost at least 80 to 90% of Boston's solid waste.⁷ The Carbon Free Boston analysis determined that a 90% 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

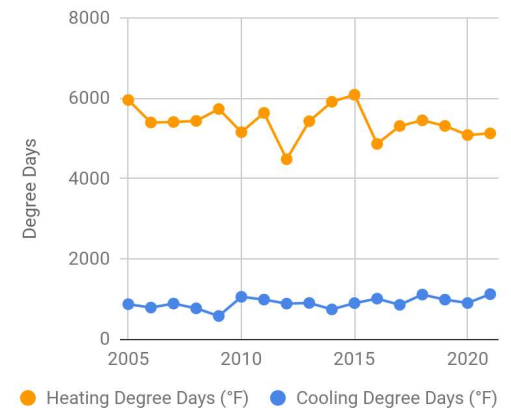


Short-term changes

From 2019 to 2021, the community's GHG emissions decreased nearly 13% (174 thousand tCO₂e), reflecting the impacts of the COVID-19 pandemic:

- The commercial sector used significantly less natural gas (or methane gas) and electricity.
- The residential sector used slightly more electricity and oil; 2021 had more cooling degree days than 2019.
- However, Boston residents, businesses and institutions used 2% less natural gas (or methane gas) than in 2018. The 2019-20 winter was slightly warmer than the 2018-19 winter.⁸
- Transportation emissions decreased due to an 18% decrease in vehicle miles traveled (VMT) between 2019 and 2020. VMT increased again by 12% between 2020 and 2021, but has not reached pre-pandemic levels.

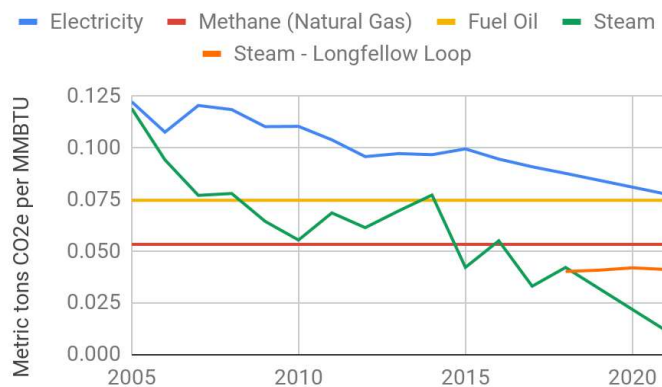
HEATING AND COOLING DEGREE DAYS



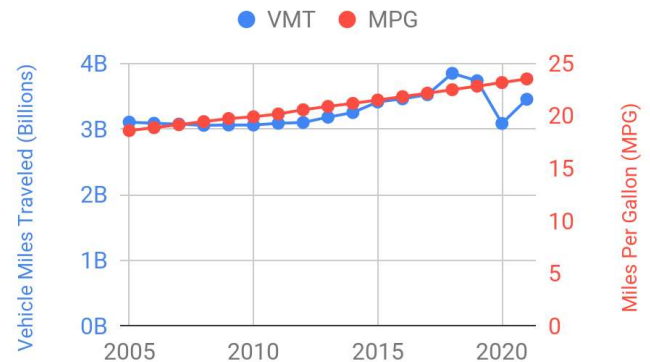
Long-term changes

Boston's GHG emissions from 2005 to 2021 have declined by 30%. Prior to the COVID-19 pandemic, about half of the reduction had been due to state-level and regional action to clean the New England electric grid. As a result, the electricity emissions factor had improved continuously over time, as electricity had become less carbon-intensive. Following the COVID-19 pandemic, only 36% of the reduction is due to a lower electric emissions factor, whereas 35% is due to reduced fossil fuel use (fuel oil and natural gas, or methane gas), 12% due to reduced electricity use and 2% due to reduced steam use. While VMT have increased since 2005, the impact of increased traffic has been counteracted by improved fuel economy, as the average vehicle registered in Massachusetts has improved from 18.6 miles per gallon (mpg) in 2005 to an estimated 23.4 mpg in 2021.⁹

GREENHOUSE GAS EMISSIONS FACTORS

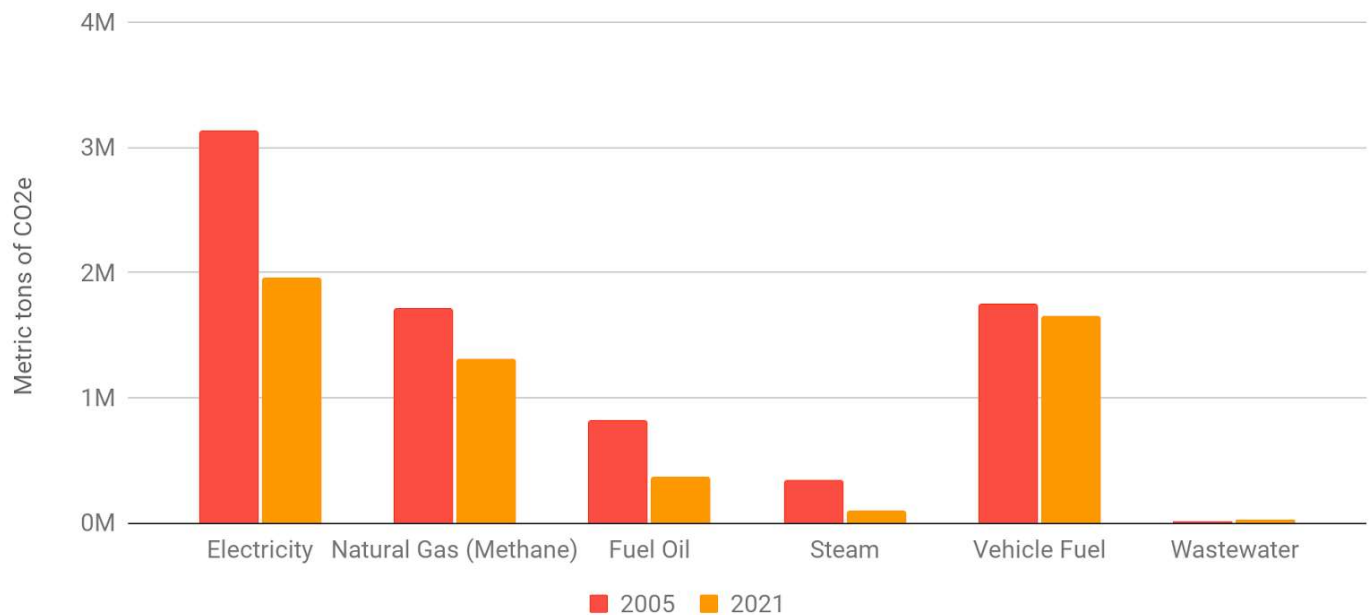


VEHICLE MILES TRAVELED AND FUEL ECONOMY



The energy efficiency efforts of the City's programs, Boston's utilities, local government and many businesses, institutions, and residents have also offset much of Boston's recent growth. The City has also adopted additional policies and programs to decrease our emissions, such as the Building Emissions Reduction and Disclosure Ordinance or the ZEV Roadmap.

EMISSIONS BY SOURCE IN 2005 AND 2021



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.¹⁰ 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 based 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

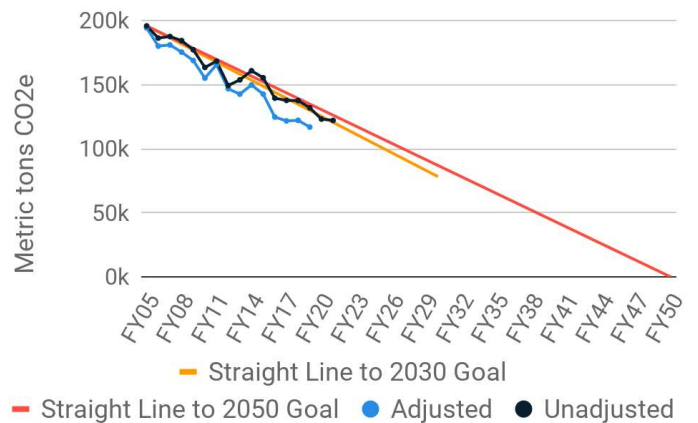
In FY2021, emissions from local government operations, or municipal emissions, had decreased by 38% from 2005. Previously, the City of Boston had purchased Green-e certified RECs, but ceased the practice in 2019; in FY2019, we purchased RECs equal to approximately one fourth of our total electricity consumption. In Fiscal Year 2023, the City evaluated options for a direct investment in renewable energy. The City of Boston met its municipal 2020 goal of a 25% reduction 5 years ahead of schedule.

EMISSIONS BY ENERGY SOURCE

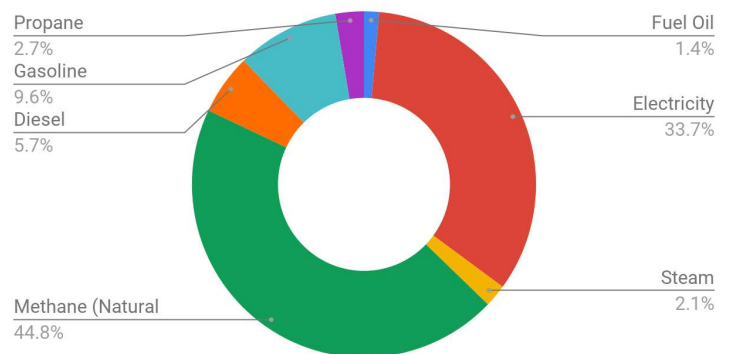
Boston’s LGO emissions are dominated by building energy consumption. Electricity and gas consumption by buildings each make up about one third of total GHG emissions. Transportation fuels, diesel and gasoline, together make up one fourth of total municipal GHG emissions.

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

LOCAL GOVERNMENT OPERATION EMISSIONS



FY21 LGO EMISSIONS BY SOURCE



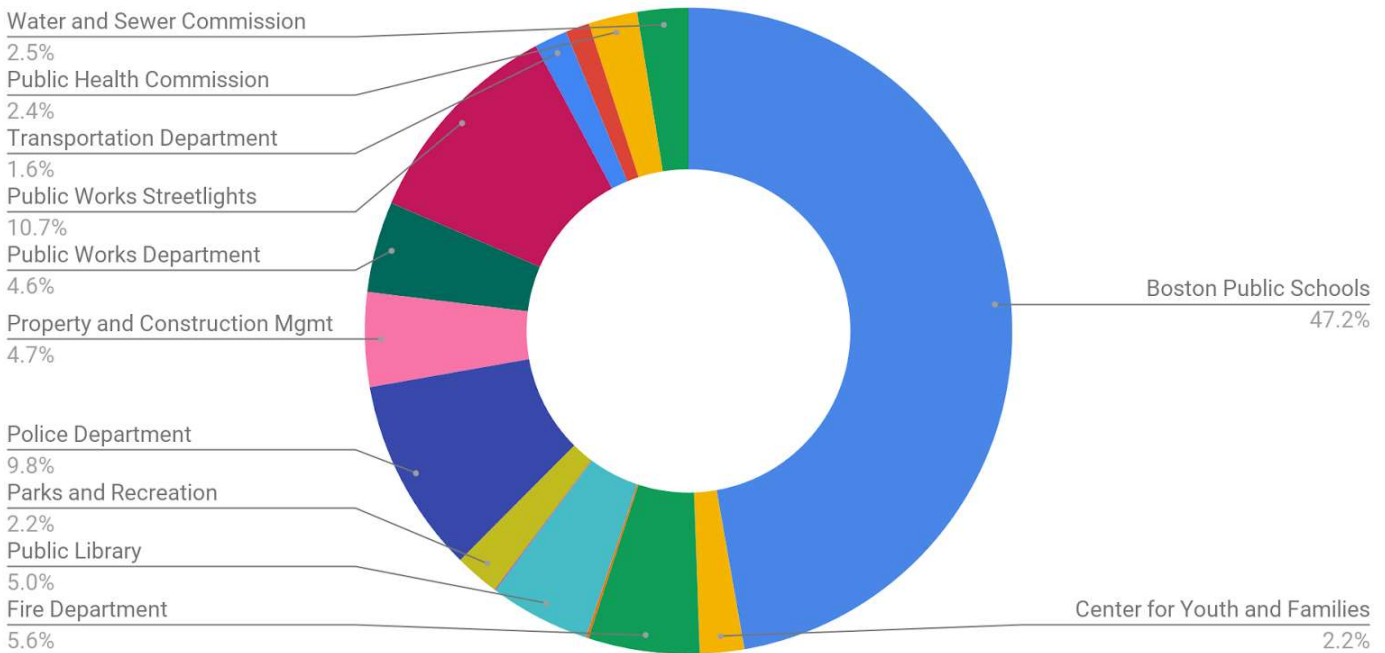
DEPARTMENTAL EMISSIONS

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 11 million of the City’s 16.5 million square feet of building space across the roughly 127 school buildings in the district.¹¹ These buildings represent over a third of municipal electricity consumption and two thirds of municipal gas consumption. The BPS Department of Transportation (DOT) fleet includes over 700 school buses and accounts for 43% of diesel fuel and 96% of propane fuel consumed by municipal government. BPS has continued their replacement of the oldest, dirtiest diesel buses to lower-emissions propane engines; propane buses represented more than half of the fleet by 2020. In 2022, BPS-DOT announced a new goal of full fleet electrification by 2030, and will pilot 20 electric school buses during the 2022/2023 school year; the impact of electric buses will begin to be reflected in the FY23 emissions inventory.

The next largest source of GHG emission from municipal operation is the Public Works Department’s street lighting inventory. The 66,000 electric street lights and the 2,800 natural gas (or methane gas) street lights (found in Boston’s historic districts) account for 10.7% 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 5% of total street light fixtures, they produce 36% of GHG emissions from street lights. In 2022, Boston piloted a new LED lamp designed to look identical to gas street lamps in Bay Village, as part of a plan to electrify gas lamps.

The third largest source of GHG emissions from municipal operations is the Boston Police Department (BPD) at about 9.8% of total municipal emissions. In FY20, BPD operated approximately 660,000 square feet of building area and managed a fleet of over 1,000 vehicles. These buildings accounted for 7% of electricity and 4% of natural gas (or methane gas) consumed by City of Boston departments. The BPD fleet accounted for roughly 56% of all gasoline consumed by City of Boston vehicles in FY20.

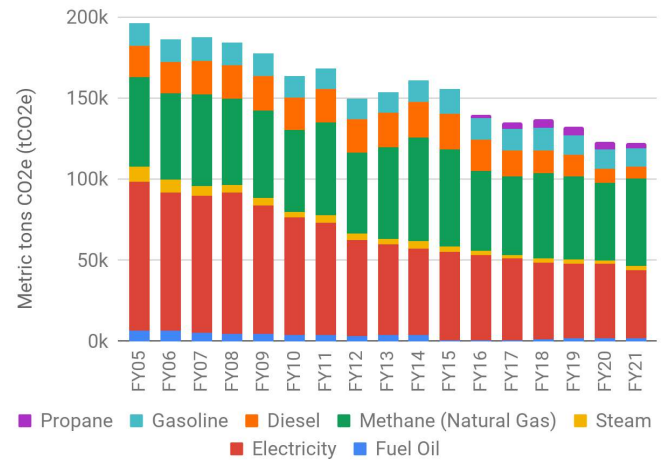
FY2021 MUNICIPAL EMISSIONS BY DEPARTMENT



FACTORS DRIVING THE CHANGES

- The electricity emissions factor has decreased since 2005 as described in the community inventory.
- Emissions from natural gas (or methane gas) and fuel oil use have decreased since FY05 as the City converted older buildings from oil to gas, and opened new, energy-efficient buildings that use natural gas or electricity for heat and hot water.
- Fuel oil use has reduced due to the closure of the Boston Public Health Commission’s Long Island facility, which relied primarily on fuel oil for heating.
- Electricity use has decreased over the long term, due to early adoption of efficient LED fixtures in the majority of streetlights. Boston also invests in building energy efficiency on a project-by-project basis, as well as through the Renew Boston Trust.¹²
- Steam use has decreased over the long term due to the reduction in steam use at City Hall and Copley Library and the conversion of the West End Branch library from steam to gas.
- BPS has shifted over half the bus fleet from diesel to propane and adopted a new goal of full fleet electrification by 2030. Propane buses offer a slight carbon benefit and reduce nitrogen dioxide (NOx) emissions by up to 95% compared to diesel, delivering significant air quality benefits.

LGO EMISSIONS BY SOURCE TYPE



INVENTORY METHODOLOGY SUMMARY

COMMUNITY INVENTORY PROTOCOL

In 2015, the City of Boston signed on to the Global Covenant of Mayors (GCoM), which required the City to follow the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). Boston’s GHG inventories are reported in CO2 equivalents (or CO2e), a universal unit of measurement that accounts for the global warming potential (GWP) of different greenhouse gasses. Boston’s inventory includes carbon dioxide (CO2), natural gas (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 Activity. Boston currently reports at the 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: Emissions that occur outside the city boundary due to activities taking place within the city boundary

Our full methodology may be found in “[Boston Greenhouse Gas Inventory Methodology](#),” most recently updated for the 2021 inventory year.¹³

2020-2021 Data Notes

- The City revised its methodology regarding the steam emissions factor. Previously, all emissions associated with steam brought into the City from the Kendall cogeneration plant were associated with the electricity generated by the cogeneration process, with no emissions associated with the steam generated, treated as a

byproduct. The emissions factor has since been updated to account for emissions associated with steam production by allocating a portion of the plant's emissions to steam production using the efficiency method. The methodology change is further detailed later in the methodology document that may be accessed on our website. The change in methodology took effect for the 2020 and 2021 inventories, and was applied to 2018 and 2019 inventories. Insufficient data is available to make the change in methodology retroactive to 2005.

- The Census Bureau did not release its standard 2020 American Community Survey 1-year estimates because of the impacts of the COVID-19 pandemic. As a result, we used the 2019 number of households with heating oil as a placeholder for the 2020 inventory. The 2021 ACS 1-year estimate was used for the 2021 inventory.
- MBTA data is largely reported based on the fiscal year rather than the calendar year.

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 (or methane 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 included.

The City uses an Enterprise Energy Management System (EEMS) to track and report local government energy consumption, cost, and GHG emissions. The EEMS allows the City to use invoice data to track progress towards energy and GHG reduction goals on a monthly basis. By closely tracking this data, the City is able to identify which departments, buildings or assets are contributing most to our overall portfolio. For vehicle fuels, fueling reports from the Department of Public Works (DPW) and Boston Fire Department (BFD) fueling stations inform fuel consumption data for various end user departments and agencies. The City reviews historical electricity, steam, natural gas (or methane gas), and fuel oil consumption every year and retroactively updates consumption figures from previous fiscal years based on the latest bill corrections and recently discovered errors. These annual adjustments are typically insignificant.

REFERENCES

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Massachusetts Water Resources Authority (MWRA)
Eversource
National Grid
Vicinity

DESIGN CREDITS

All graphics produced using Google Sheets.

Please direct comments or questions about the inventory to: environment@boston.gov