Credit: Jonas Kahn

CITY OF SOMERVILLE

GREENHOUSE GAS INVENTORY REPORT

January, 2016

SustainaVille
creating a resilient & carbon neutral somerville

CITY OF SOMERVILLE

GREENHOUSE GAS INVENTORY REPORT

Prepared by:

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Foreword

With sea levels already beginning to rise, and extreme weather events becoming more frequent, it's clear that climate change is already happening and we must take action now to reduce its impacts in the future. Cities can and should lead the way in this effort to protect our environment for future and present generations—and we must be bold. The City of Somerville set the ambitious goal last year to achieve carbon neutrality as a city by 2050. Carbon neutrality is critical to safeguarding our future, but it also presents an opportunity to innovate, improve our quality of life, and expand our economy. But to do this effectively, we need the right data and information to guide our decision making and track our progress. This Greenhouse Gas Inventory is a critical first step in our information gathering.

While we are already taking steps toward reaching our carbon goals through energy efficiency, our new Somerville GreenTech program, electric vehicle charging stations, and more, this Greenhouse Gas Inventory represents a critical step in our efforts to achieve carbon neutrality by giving us a clear diagnosis of the issues we must tackle. This foundational document is helping us measure what we need to achieve in each sector to reach our goals, so that we can determine the most effective steps to take to get to carbon neutrality.

This inventory shows that without action, our emissions will continue to rise in our energy, transportation, waste, and local government sectors. Turning that trend around and getting to zero will not be easy, but I know that together we have the knowledge, creativity, and determination to tackle this challenge.

Building upon this baseline analysis, we will continue to measure our municipal operations and community emissions on a regular basis to track our progress toward 2050—and to make smart decisions on how to reach our 2050 goals. Together, we will use this valuable information to make Somerville a resilient and carbon-neutral city.

Mayor Joseph A. Curtatone

Somerville's GHG Emissions - 2014

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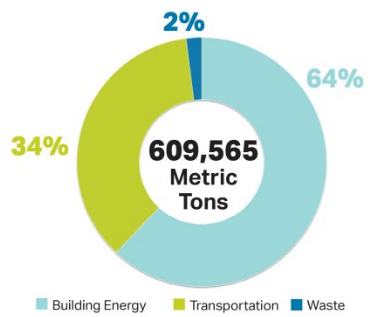
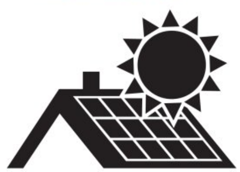
Community Inventory

Greenhouse Gas Emissions Profile



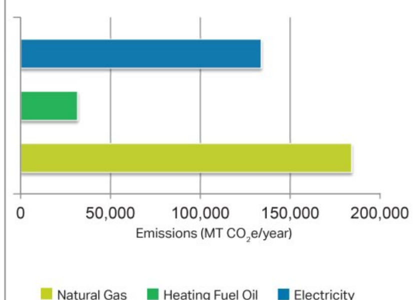
Split of Building Energy Emissions

Equivalent Solar Installations



Approximately 139,900 residential solar systems would be required to avoid Somerville's total Community emissions. That is four times the number of homes in the city.

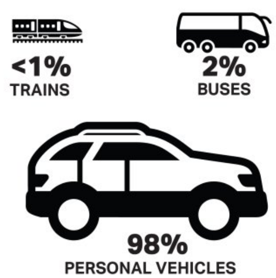
Building Energy Emissions by Energy Type



Absorbing GHG Emissions

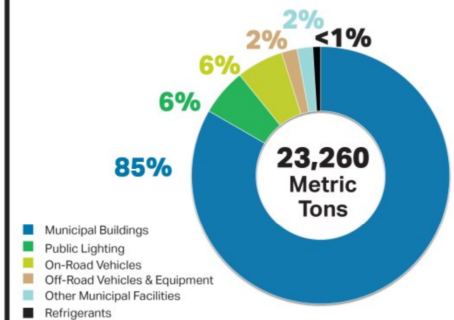
A forest 185 times larger than the City of Somerville would be required to sequester the total community emissions for one year!

Split of Transportation Emissions

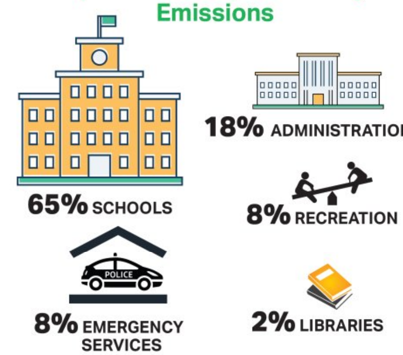


Local Government Inventory

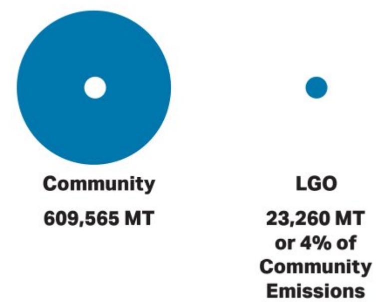
Greenhouse Gas Emissions Profile



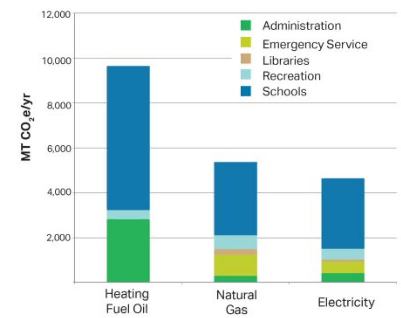
Split of Municipal Building Emissions



Comparison of 2014 Base Year Community and LGO Emissions



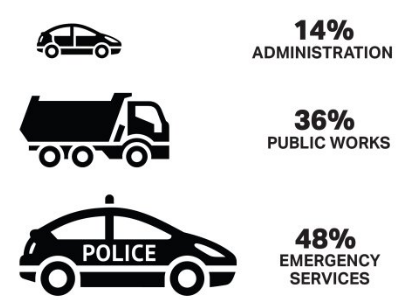
Municipal Building Emissions by Energy Type



What is in the Inventory?

SCOPE 1	What we combust (e.g., heating oil, transport fuel)
SCOPE 2	Purchased emissions from energy we consume (e.g., grid supplied electricity and natural gas)
SCOPE 3	Other indirect emission (e.g., waste disposal, wastewater treatment losses from energy transmission)

Split of On-Road Vehicle Transportation Emissions



INTRODUCTION

The City of Somerville (the City) is located in Middlesex County, Massachusetts, two miles northwest of Boston. The City covers an area slightly over 4 square miles. Somerville is known for its many city squares which help mark neighborhood boundaries including Davis Square, Union Square, Ball Square, Teele Square, and Magoun Square. In 2014, the population of the City was 78,900, and is projected to grow 22% by 2035. Similarly, there were nearly 25,000 local jobs in Somerville in 2014. Local employment is also anticipated to grow 22% by 2035.

Somerville recognizes the challenges that climate change presents and acknowledges that cities can and should lead the way in efforts to protect our environment for future and present generations. The City has set the ambitious goal to achieve carbon neutrality as a city by 2050. Many actions have been taken to work towards achieving this goal including:

- Increase in use of electric vehicles in the City fleet and the installation of public electric vehicle charging stations in Davis Square, Union Square, and City Hall.
- Investment in bicycle facilities and continual increase in cycling rates.
- $2.2 million investment in LED streetlights.
- Residential Energy Efficiency Program that resulted in 560 homes audited; $96,000 in incentives delivered to 73 homes.
- Somerville Energy Efficiency Now (SEEN) launched in Fall 2015 to increase resident and landlord adoption of energy efficiency measures that are incentivized through state programs.
- Somerville GreenTech program launched in 2015 to engage the green tech industry in municipal collaborations that address climate change.
- In 2008, the City began a 20-year, $7.8 million performance contract that covered 19 municipal buildings.
- Energy efficient LED lighting has been installed in City buildings.

- 90 kW of solar capacity on three schools (Argenziano, Capuano, High School).
- Somerville was designated a Green Community by the MA Department of Energy Resources in 2011.

The Emissions Inventory

The City of Somerville (the City) developed two sets of emissions inventories for the 2014 base year. The community inventory represents total emissions from activities occurring within City limits, such as vehicle trips, home and business energy use, and solid waste generation. The local government operations (LGO) inventory represents a subset of the community inventory, and illustrates the emissions generated as a direct result of City government actions. For example, the LGO emissions from energy consumption are included in the Community energy data, and transportation emissions resulting from operation of the City's vehicle fleet is also accounted for in the community traffic data model. Both inventories were forecast to future years to estimate how emissions will grow within the community and local government. These inventories, along with the analysis included in this report, will serve as the basis for developing a comprehensive emissions reduction strategy for the City of Somerville.

Components of Report

This report is presented in three sections, beginning with an introduction to the emissions inventory process and its purpose. The other two sections present the results and analysis from each inventory. These two inventory sections describe the specifics of the emissions sectors that were analyzed, present the baseline inventory and future year forecast results, and identify the major emissions sources that may inform future emissions reduction actions and strategies.

Purpose of Emissions Inventories

Preparation of an emissions inventory serves as the starting point for developing a comprehensive emissions reduction strategy to meet the long-term goal of achieving a carbon-neutral Somerville by 2050. The inventories presented within this report establish a baseline against which to measure progress towards that goal.

Overview of Greenhouse Gas Inventory Methodology

Emissions inventories provide a snapshot of the amount and source of greenhouse gas emissions in a given year. The base year inventory serves as a reference point for reduction targets and is used to estimate future emissions levels, or forecasts. Future inventory updates can demonstrate progress toward established reduction targets and help to assess the effectiveness of City strategies and actions.

The City prepared base year inventories for the 2014 calendar year. The community inventory adheres to guidance provided in the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories* (GPC). The LGO inventory followed additional guidance provided in the *Local Government Operations Protocol, Version 1.1.* Both inventories are aligned with the requirements of the international Compact of Mayors, which Somerville joined in September 2015.

The GPC provides guidance on how to standardize emissions inventories.

The following sections give an overview of the emissions measurement process and sectors analyzed in each inventory. Additional details on the emissions reporting protocols, inventory methodologies, and data sources are provided in a supporting Technical Memorandum that is available separately.

Emissions Measurement

Emissions inventories are commonly expressed in metric tons (or tonnes) of carbon dioxide equivalent per year (MT CO_2e/yr) to provide a standard measurement that incorporates the varying global warming potentials (GWP) of different greenhouse gases. GWP describes how much heat a greenhouse gas can trap in the atmosphere relative to carbon dioxide, which has a GWP of 1. For example, methane has a GWP of 28, which means that 1 metric ton of methane will trap 28 times more heat than 1 metric ton of carbon dioxide, making it a more potent greenhouse gas. Some gases used in industrial applications can have a GWP thousands of times larger than that of CO_2. In order to maintain consistency within each inventory and between the baseline and projected emissions inventories, all GHG emissions have been quantified in units of MT CO_2e/yr.

Further, emissions can be described as direct or indirect, depending upon where the emissions generation occurs (refer to the Scope 1, 2 and 3 information outlined in the Executive Summary). Direct emissions are those where the consumption activity directly generates the emissions, such as natural gas combustion for heating or cooling (e.g., Scope 1). In this instance, natural gas can be consumed on-site and the resulting emissions are a direct result of that consumption. Indirect emissions are those where the consumption activity takes place within the jurisdiction, but the actual emissions generation occurs outside of that boundary. For example, a Somerville resident can consume electricity within their home, but that electricity may be generated in an area outside of the City's jurisdiction (e.g., power plants throughout Massachusetts) (Scope 2).

The baseline emissions inventories were prepared using a combination of empirical and modeled data, depending on its availability. Data was collected from many sources including City data records, utility company reports, the Massachusetts Department of Environmental Protection, the Massachusetts Water Resources Authority, and the Boston Region Metropolitan Planning Organization. Data was then converted into greenhouse gas estimates using relevant emissions factors.

Emissions were calculated using the following equation:

*Amount of Activity * Emissions Factor = Emissions*

Where an activity includes items such as, electricity consumed (i.e., kilowatt hours/yr), vehicle miles traveled, gallons of wastewater generated.

Emissions Sectors

The inventories are organized into categories, or sectors, that represent the commonly understood, major sources of emissions. These sectors are largely consistent between the community and LGO inventories, though naming conventions differ slightly, as guided by the relevant Protocols. Somerville's community inventory includes emissions from the following sectors:

- Stationary Energy (i.e., electricity and natural gas)
- Transportation
- Waste
- Fugitive Emissions from Natural Gas.

The LGO inventory includes slightly different sectors, to more clearly reflect the emissions sources relevant to the services provided by the City:

- Municipal Buildings (electricity and natural gas)
- Other Municipal Facilities (electricity)
- Public Lighting
- On-Road Vehicles
- Off-Road Vehicles and Equipment
- Process and Fugitive Emissions.

Scope Limitations

The inventories presented in the report cover the material and significant sources of emissions across the sectors outlined in the relevant Protocols. However, in defining the scope, the following emissions were excluded:

<u>Community Inventory</u>

- Industrial sector emissions were not included as there is minimal industrial activity in the City, and a reliable and publicly available data source of industrial fuel consumption is currently unavailable.
- Emissions from waste recycling processes were excluded due to the difficulty in obtaining activity and emissions data.
- Scope 1 and 2 air travel emissions were not included because there is no airport within the City's boundaries. Scope 3 emissions associated with Somerville residents traveling through regional airports can be voluntarily reported, but were not included in the inventory due to the difficulty in obtaining accurate activity data at the community level.

<u>LGO Inventory</u>

- City employee commute emissions were not included as they are accounted for in the transportation sector emissions in the Community Inventory
- Emissions associated from waste generated by LGO operations were not quantified as a separate source of emissions as they are included in the Community Waste Sector emissions
- City employee business-related air travel by can be voluntarily included, but is typically omitted by smaller local governments like Somerville to focus analysis on the most significant emissions sources.

Future emissions inventories may be enhanced by:

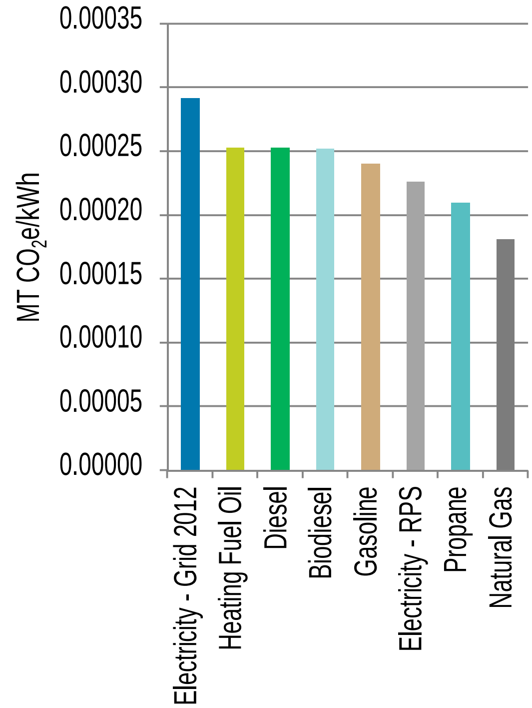
- Including emissions from electric vehicles in the LGO On-Road Vehicles Sector.
- Reviewing data collection information to refine the allocation of 'other' electricity account data in the Other Municipal Facilities and Public Lighting Sectors (combined, the 'other' accounts are approximately 2% of the total LGO emissions).

- Reporting on the electricity generated, and emissions avoided by the generation of electricity from City owned solar installations.

Fuel Sources

The community and LGO emissions are also analyzed according to their fuel sources to highlight opportunities for focusing future reduction actions. Figure 1 illustrates the relative emissions potential of the fuel types analyzed in this report. As shown, electricity consumption in the base year generated the highest emissions per unit of energy of any fuel source analyzed in Somerville's inventories, while natural gas generated the lowest. This is due to the mix of fuel sources used to generate electricity sold in Massachusetts. While natural gas may have the lowest emissions intensity of the identified energy types, approximately two percent of the natural gas consumed leaks from the distribution network. Natural gas leaks (i.e., fugitive emissions) create more GHG emissions than if the same amount of natural gas is combusted. This is because combusted natural gas emissions consist mostly of carbon dioxide, while non-combusted natural gas is mostly methane and methane has a global warming potential 28 times more than carbon dioxide.

Figure 1 – Emissions Intensity per Kilowatt Hour per Energy Type



Source: AECOM 2015

Note: Electricity – Grid 2012 represents the energy intensity of grid electricity during the base year (based on the most current eGRID report); Electricity – RPS represents the future grid electricity energy intensity following implementation of the Massachusetts Renewable Portfolio Standard requirements for 20% of electricity to be provided by renewable sources by 2025.

Community Inventory and Forecasts

The community inventory estimates the total amount of emissions generated from activities within the City of Somerville boundary. The inventory represents emissions from residential, commercial, institutional, and public activities. This section introduces the emissions sectors used to organize the community inventory. It then presents the 2014 base year community inventory and describes sub-sector emissions, as necessary, to provide greater detail on how emissions are generated in Somerville. Emissions forecasts are then presented to demonstrate how emissions are anticipated to grow through the year 2050. Finally, the primary sources of community emissions are described.

Emissions Sectors and Subsectors

The community inventory is organized into the following sectors to describe the primary sources of emissions in the community. A supporting Technical Memorandum is available that provides additional details of these sectors, the emissions reporting protocol, and data sources used to guide preparation of this inventory.

Stationary Energy

The Stationary Energy sector includes emissions generated as a result of energy consumption in homes, offices, schools, stores, and other buildings within the community. Emissions result from the consumption of electricity transmission through the utility grid, as well as direct combustion of natural gas and heating fuel oil. This sector also includes energy-related emissions attributed to the community's share of wastewater treatment and potable water conveyance.

The Stationary Energy sector is organized into four sub-sectors: residential buildings, commercial and institutional buildings, non-specified energy use, and fugitive emissions from natural gas conveyance. The non-specified energy use relates to electricity consumption for potable water and wastewater treatment and conveyance.

Transportation

The Transportation sector represents mobile emissions associated with vehicle use on community roadways, off-road equipment emissions (e.g., forklifts, lawnmowers), and the community's share of rail transit emissions. The community's on-road transportation emissions come from vehicle trips that begin and/or end within Somerville's boundaries. Pass-through trips (for example, non-local drivers on Interstate 93) are not included within the emissions inventory because they do not occur as a result of community activity (e.g., jobs, retail, housing in Somerville).

The Transportation sector includes three sub-sectors: on-road transportation, off-road equipment, and railways.

Waste

The Waste sector includes emissions associated with solid waste disposal and biological process emissions resulting from wastewater treatment (separate from the energy-related wastewater treatment emissions included in the Stationary Energy sector). Solid waste collected in the community is sent to the Wheelabrator Saugus Inc. waste-to-energy facility where it is incinerated to generate electricity. Waste collection and hauling activities also generate GHG exhaust emissions. However, hauling-related emissions, including those related to private haulers associated with large multi-unit residential buildings, are assumed to be included within the transportation model and represented within the Transportation sector. It is acknowledged that recycling of solid waste also produces greenhouse emissions. However, these emissions have not been included in the scope of this inventory due to the complexity involved in producing an emissions estimate.

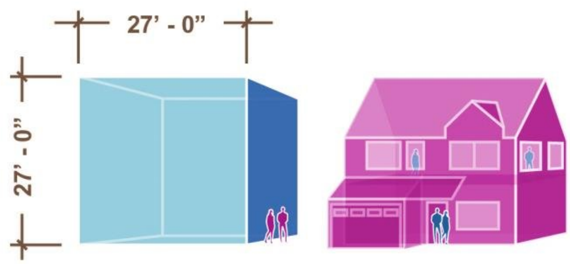
Wastewater treatment generates emissions resulting from treatment processes and from energy used to power wastewater treatment plants. While there is no wastewater treatment facility within the community, the emissions reporting protocol recommends calculating the community's share of emissions associated with this activity. Treatment of wastewater influent can generate methane (CH_4) emissions, while discharged effluent can generate nitrous oxide (N_2O) emissions. Both of these emissions sources are considered direct process emissions, and are included in this sector.

The Waste sector includes two sub-sectors: solid waste incineration and wastewater treatment and discharge.

Base Year Inventory

Analysis of emissions sources can help to identify opportunities for reducing future emissions levels in order to achieve our community's long-term carbon-neutral goal. Community activities in Somerville generated approximately 609,565 MT CO_2e in the 2014 base year. However, understanding the scale of a community's emissions can be challenging. The EPA created a greenhouse gas equivalencies calculator to help convert annual emissions into more accessible concepts. Figure 2 illustrates the scale of one metric ton of carbon dioxide as compared to a single-family house.

Figure 2 – How Large is One Metric Ton of CO_2?



One metric ton of carbon dioxide would fill a cube 27 feet tall! That's about the size of a two-story home, totaling more than 1,400 square feet.

In addition to understanding the scale of a single metric ton of carbon dioxide, Somerville's total emissions inventory can also be compared to other more common metrics. For example, it would take more than 499,640 acres of U.S. forest one year to sequester the total community base year emissions.[1] As depicted in Figure 3, the resulting forest would be more than 185 times larger than the City of Somerville.

Figure 3 – Carbon Sequestration

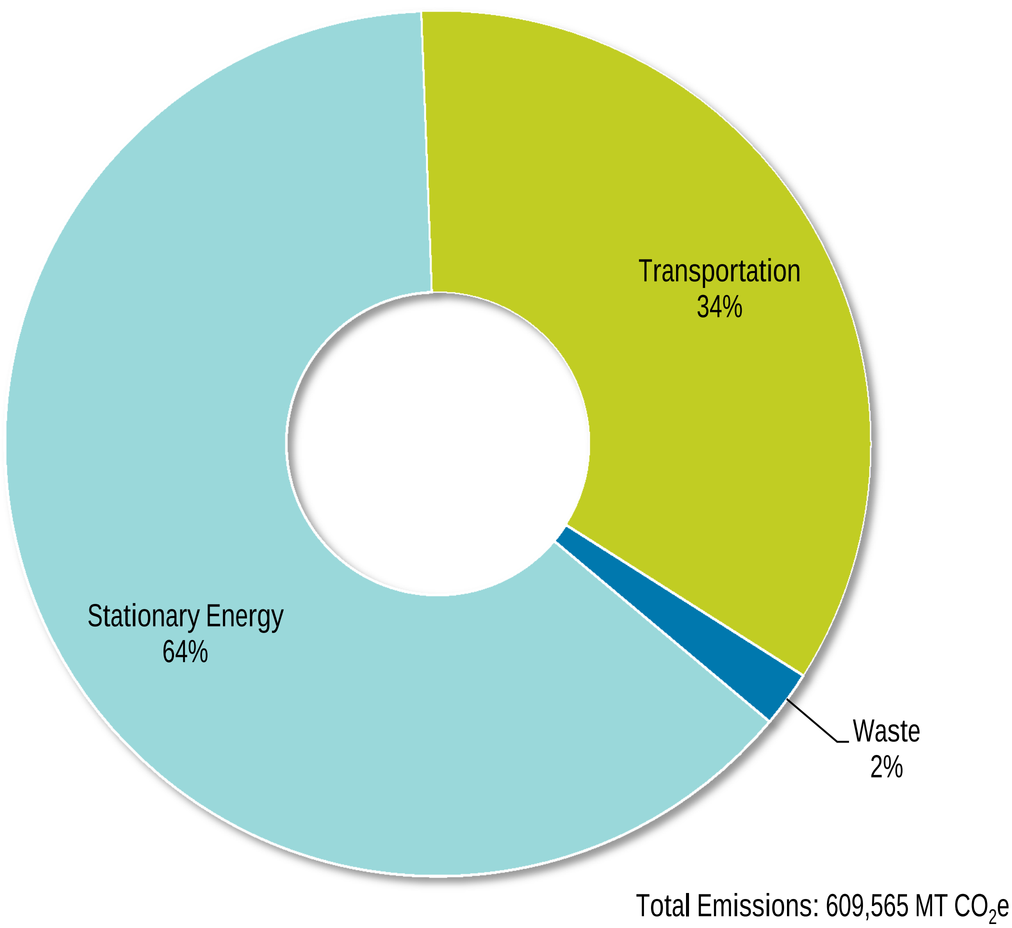
A forest more than 185 times larger than the City of Somerville would be required to sequester the total community emissions for one year!

Alternatively, if the entire inventory were represented as home energy use, then it would take a community of 55,615 homes to generate the same amount of emissions as Somerville's base year inventory. For comparison, the City had approximately 32,745 homes in the 2014 base year. Another way to look at it is that approximately 139,900 residential solar systems would be required to avoid Somerville's total Community emissions. That is four times the number of homes in the City.

As shown in Figure 4 on the following page, Stationary Energy emissions were the largest contributor to the community inventory, providing 64% of total emissions. Transportation emissions contributed an additional 34%, with the Waste sector responsible for the remaining 2% of community emissions. Analysis of the community inventory sub-sectors is provided on the pages following Figure 4.

[1] U.S. Environmental Protection Agency, Greenhouse Gas Equivalencies Calculator. Available online: http://www2.epa.gov/energy/greenhouse-gas-equivalencies-calculator. Accessed November 1, 2015.

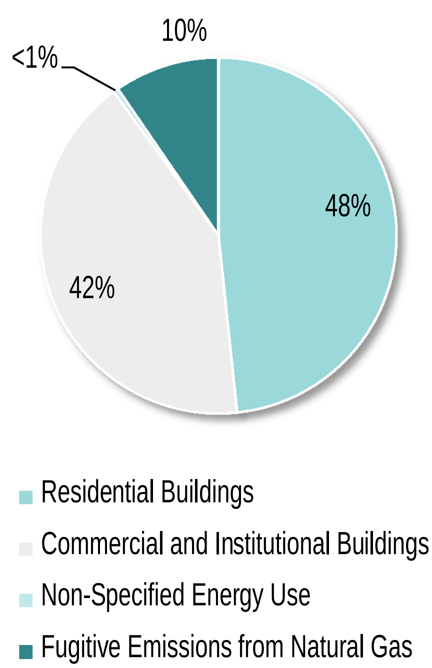
Figure 4 – Community 2014 Base Year Greenhouse Gas Emissions Inventory



Stationary Energy

Building-related emissions account for 98% of total Stationary Energy sector emissions (Figure 5). Residential buildings generate approximately half of the emissions (48%), and commercial and institutional buildings provide an additional 42%. Fugitive emissions (e.g., leaks) related to the conveyance of natural gas within the community contribute 10% of sector emissions[2], while other non-specified energy uses provide less than 1%. The non-specified energy use sub-sector represents electricity consumption related to potable water treatment and wastewater treatment and conveyance.

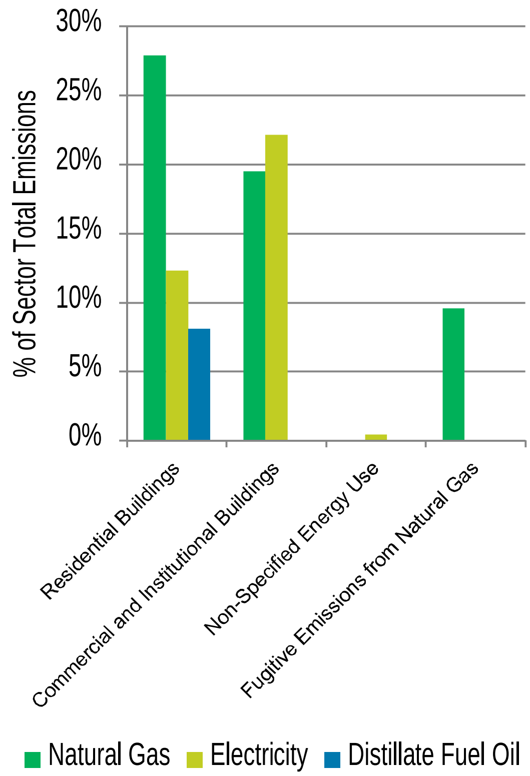
Figure 5 – Stationary Energy Emissions by Sub-Sector



[2] For the purpose of this inventory, fugitive emissions from the conveyance of natural gas are estimated using general assumptions and are not an attempt to quantify emissions from leaks specifically within the City of Somerville.

The Stationary Energy sector can also be analyzed according to the type of energy used (Figure 6). Natural gas combustion and fugitive emissions generated more than half of the sector's emissions. Electricity contributed 33% of emissions, and heating fuel oil (i.e., distillate fuel oil) provided 8%. Within the residential sub-sector, natural gas and heating oil together contributed 76% of the sub-sector emissions. This suggests that reduction strategies might focus on increasing thermal efficiency within the community's housing stock. The commercial and institutional sub-sector is more evenly split between emissions from electricity (51%) and natural gas (49%).

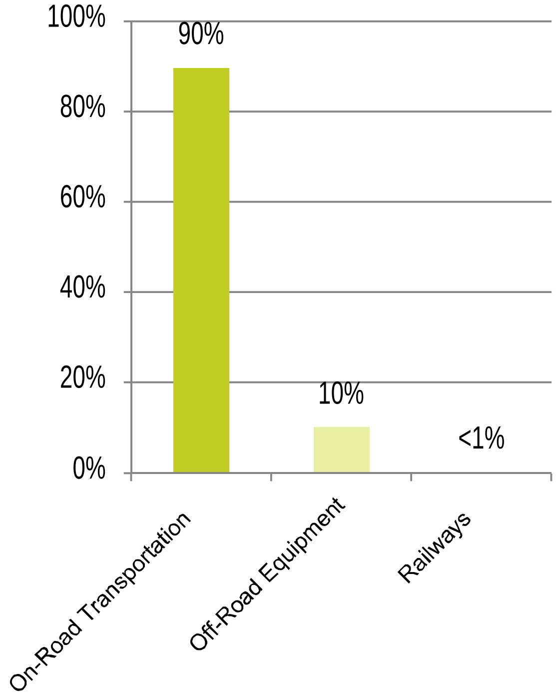
Figure 6 – Stationary Energy Emissions by Energy Type



Transportation

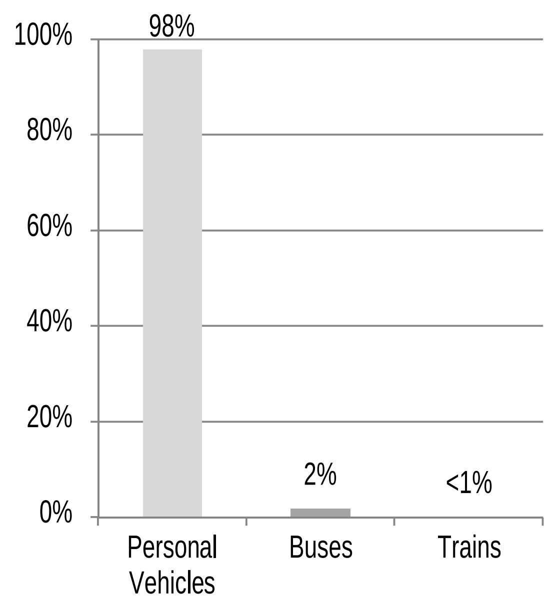
Transportation sector emissions account for 36% of total community emissions. As shown in Figure 7, the majority of transportation emissions come from on-road vehicles driving on roadways within the community (90%). Off-road equipment, such as lawnmowers and forklifts, provide another 10% of sector emissions. Less than 1% of Transportation sector emissions are the result of railway operations associated with trips by Somerville's residents and employees.

Figure 7 – Transportation Emissions by Sub-Sector



Somerville's transportation emissions can also be viewed as personal transportation versus public transportation. Figure 8 excludes off-road equipment emissions to show that the overwhelming majority (98%) of vehicle-related emissions is from the operation of personal vehicles on Somerville's roadways. Buses contribute approximately 2% of vehicle emissions, while trains make up less than 1% of emissions.

Figure 8 – Personal and Public Transportation Emissions

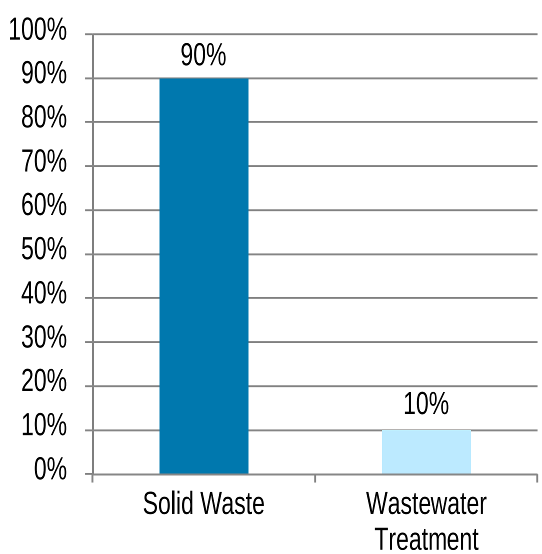


Waste

Accounting for 2% of total community emissions, the Waste sector includes emissions from solid waste incineration and biological process emissions related to wastewater treatment. All of Somerville's solid waste is incinerated to generate electricity at the Saugus waste-to-energy facility. The associated emissions from this incineration contribute 90% of the Waste sector emissions (Figure 9). The remaining 10% of emissions is related to Somerville's share of wastewater sent to area treatment facilities outside of City limits.

The City's Waste sector emissions are lower than a comparable city that sends their waste to landfill. This is because the relative emissions from the incineration of food and paper waste are significantly lower than those related to the methane generated from the decomposition of these materials in a landfill.

Figure 9 – Waste Emissions by Sub-Sector



Emissions Forecasts

The base year emissions are forecast for three future planning years to estimate how emissions will grow in the community through the City's long-term target year of 2050. Emissions were forecast for the years 2020, 2035, and 2050 to provide near-, mid-, and long-term emissions estimates. The forecasts were based on population and employment growth estimates developed by the Boston Region Metropolitan Planning Organization (MPO) in support of its regional transportation planning efforts.

Business-as-Usual Forecasts

Emissions are typically forecast under a business-as-usual (BAU) scenario, which assumes that no emission-reduction actions will be undertaken beyond those already in place in the base year. This approach allows for analysis of a community's full emissions growth potential before identifying emissions reduction strategies. BAU emission forecasts are useful to provide insight regarding the scale of reductions necessary to achieve an emissions target before considering reductions likely to result from federal and statewide actions (e.g., vehicle efficiency standards), inherent technological advancements (e.g., energy-efficient appliances, lighting technology), or new local voluntary or mandatory conservation efforts (e.g., green building requirements). The BAU emission forecasts also do not anticipate new sources of emissions or increased consumption rates in existing sectors. For example, as use of personal electronics increases, such as smartphones and tablets, emissions from electricity plug-load may also increase. Therefore, the only variable influencing the BAU forecasts is projected population and employment growth within the city.

However, in the case of Somerville's emissions forecast, the transportation data made available to the City during inventory preparation already included the emissions-reducing effects related to implementation of the Massachusetts Low Emission Vehicle Program (LEV). This statewide program will act to reduce future vehicle emissions by increasing vehicle efficiency requirements beyond those in the base year. It was not possible to estimate community transportation data for future planning years exclusive of these expected reductions.

Consideration of these Transportation sector emissions reductions results in lower emissions growth in each of the forecast years than would otherwise have been estimated under a traditional BAU scenario.

Community emissions are estimated to increase from 2014 base levels by:

- 0.8% by 2020,
- 0.6% by 2030, and
- 27.6% by 2050.

Adjusted Business-as-Usual Forecasts

Once BAU emissions forecasts have been established, adjusted-business-as-usual (ABAU) forecasts are typically prepared to demonstrate the results of implementing known state and federal emissions reduction programs.

In addition to the previously mentioned LEV program, this inventory analysis also considered the future impact of the Massachusetts' Renewable Energy Portfolio Standard (RPS). The RPS will result in lower electricity emissions by requiring 20% of electricity sold in Massachusetts to be generated from renewable sources (i.e., emissions-free) by 2025.

The forecasts presented in the remainder of this section represent ABAU emissions levels based on statewide implementation of the LEV program and the RPS.

As previously described, while allowances have been made for known policies (e.g., LEV and RPS), the forecasts do not take into account unpredicted changes that may occur, such as significant national or global emissions reduction commitments or specifics of transportation policies or infrastructure improvements (e.g., the Greenline expansion). Refer to the supporting Technical Memorandum for further detail on how community emissions growth assumptions were developed and applied to the base year inventory.

Somerville's Emissions Forecasts

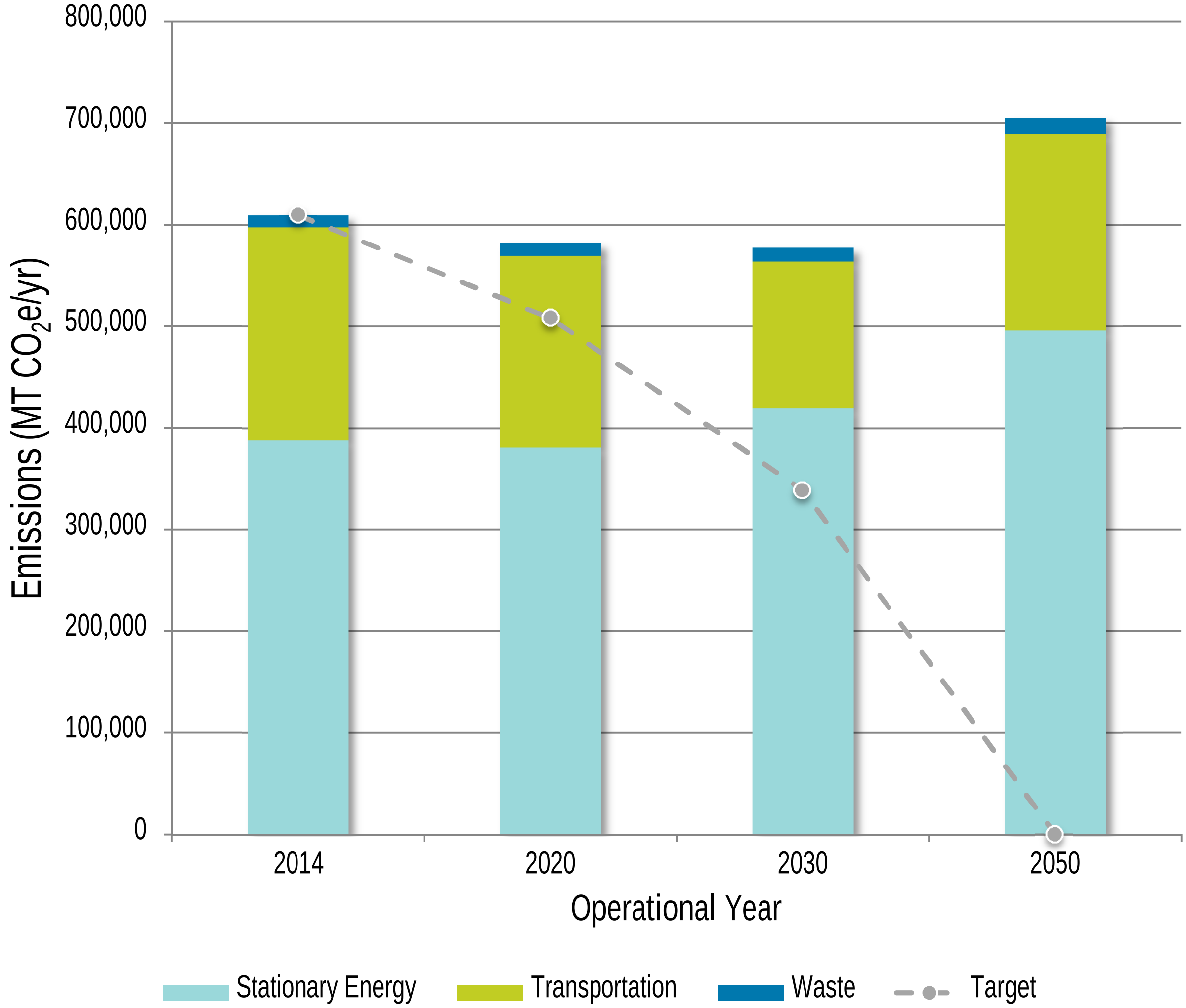
As shown in Table 1 on the following page, community emissions are forecast to grow from 609,565 MT CO_2e in 2014 to 705,150 MT CO_2e in 2050. This represents 16% growth from the base year inventory, or approximately 0.4% growth per year.

Figure 10 illustrates emissions growth by sector for each of the planning years. It also overlays an emissions target trajectory consistent with the Mayor's long-term goal for zero-emissions by 2050. This target line shows what emissions levels would need to be in each planning year if a straight line was drawn from the 2014 base year emissions level to zero-emissions in 2050. Target achievement would require annual emissions reductions of approximately 17,415 MT CO_2e/yr from the base year, as opposed to the estimated emissions increase of 2,730 MT CO_2e/yr shown in the forecast table.

Table 1 – Community Emissions Inventory and Forecasts (Adjusted Business-as-Usual)

Sector	2014 (MT CO_2e)	2020 (MT CO_2e)	2035 (MT CO_2e)	2050 (MT CO_2e)
Stationary Energy	388,470	381,185	419,440	495,935
Residential Buildings	*187,745*	*188,400*	*207,260*	*244,980*
Commercial and Institutional Buildings	*161,755*	*151,750*	*167,030*	*197,580*
Non-Specified Energy Use (Water / Wastewater)	*1,790*	*1,480*	*1,630*	*1,925*
Fugitive Emissions from Natural Gas	*37,180*	*39,555*	*43,520*	*51,450*
Transportation	209,260	188,180	144,535	192,840
On-Road Transportation	*187,670*	*165,285*	*119,345*	*163,060*
Off-Road Equipment	*310*	*255*	*280*	*330*
Railways	*21,280*	*22,640*	*24,910*	*29,450*
Waste	11,835	12,590	13,850	16,375
Solid Waste Incineration	*10,640*	*11,320*	*12,450*	*14,720*
Wastewater Treatment and Discharge	*1,195*	*1,270*	*1,400*	*1,655*
TOTAL	609,565	581,955	577,825	705,150

Figure 10 – Community Emissions Forecasts (Adjusted Business-as-Usual)



Community emissions are estimated to decrease from 2014 to 2020 as a result of emissions reductions from the LEV and RPS programs. Beyond the 2020 planning year, community population and employment growth will offset reductions from these statewide programs and lead to emissions increases from 2020 through 2050, assuming these programs are not enhanced (i.e., made more stringent) and additional emissions reduction programs are not implemented.

Priority Emissions Sources

As shown throughout this section, community emissions are primarily a result of building energy consumption and on-road transportation in the community. The boxes below trace two primary emissions sources from the sector level to a specific fuel type or end use. This type of analysis establishes a framework for defining future emissions reduction strategies. For example, strategies designed to increase the thermal efficiency of the community's buildings would address nearly one-quarter of total emissions, as shown in the first box. Similarly, strategies that result in increased vehicle efficiency, alternative fuel vehicle use, or alternative transportation options would affect nearly one-third of total emissions, as shown in the second box.

2014 STATIONARY ENERGY USE

- 64% of total emissions

Residential building energy use

- 31% of total emissions

Natural gas use in residential buildings

- 18% of total emissions

2014 TRANSPORTATION USE

- 34% of total emissions

On-road transportation

- 31% of total emissions

Passenger vehicles and trucks

- 30% of total emissions

Community emissions reduction opportunities can also be assessed based on the type of energy used. Figure 11 shows that natural gas and diesel/gasoline each provide approximately one-third of community emissions, electricity contributes another 2%, and heating fuel oil is responsible for 5% of total emissions. The remaining 2% of community emissions come from the Waste sector (non-fuel emissions sources) and unspecified fuel types in the off-road equipment sub-sector.

With nearly one-quarter of total emissions related to community electricity use, the portfolio of electricity sources supplied to the grid influences Somerville's emissions. If electricity on the grid can be generated from greater amounts of renewable sources and fewer amounts of carbon-intense fuels, then another primary emissions source can be mitigated.

Figure 11 – Community Emissions by Energy Type

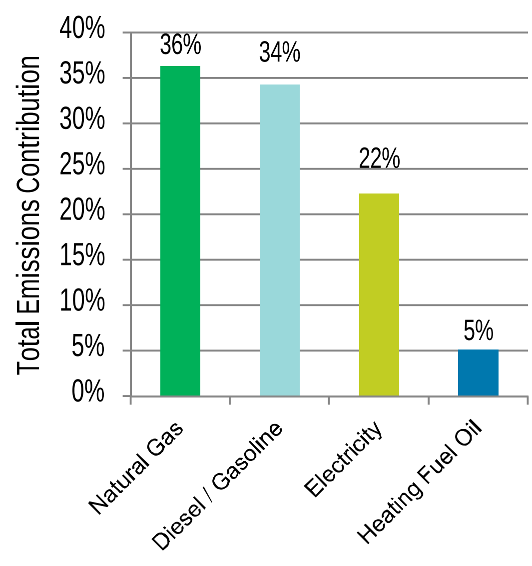
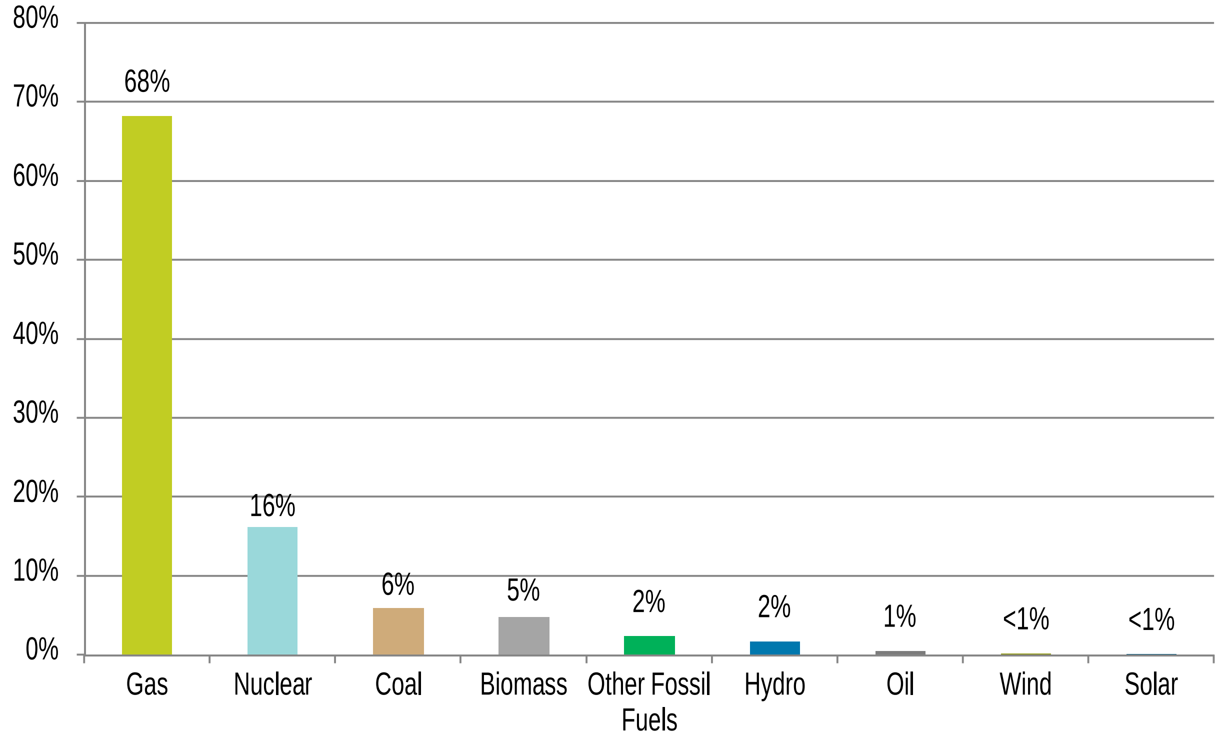


Figure 12 shows the mix of electricity sources used in the base year inventory. Over time, as implementation of the RPS increases, the proportion of fossil fuel energy sources (e.g., gas, coal, oil) in the electricity portfolio is projected to decrease, while the share of renewable sources (e.g., hydro, wind, solar) increases. The result will be lower community electricity-related emissions.

During the emissions reduction strategy development phase, the City may identify local opportunities to accelerate this transition toward a lower-carbon electricity grid, or define pathways to exceed the current RPS requirements to realize greater emissions reductions in the local inventory.

Figure 12 – Massachusetts Electricity Portfolio Sources – 2012



Source: eGRID 2012, State Resource Mix for Massachusetts


Credit: Jonas Kahn

Local Government Operations Inventory and Forecasts

The City of Somerville is responsible for providing a variety of services to community residents and businesses that keep the City running and maintain our unique character. The provision of these services results in building energy consumption, lighting and other facility electricity use (e.g., fire pumps and traffic control boxes), vehicle and equipment operation, and chemical refrigerant use. The LGO inventory described here estimates the emissions related to the provision of these services.

This section first describes the LGO inventory emissions sectors that are included in this analysis. The results of the base year inventory are then presented with additional detail provided for certain sub-sectors based on data availability. Future year emissions forecasts are then presented to demonstrate how emissions are likely to grow. Finally, the section concludes with a high-level analysis of the primary emissions sources in the LGO inventory, which can inform future City efforts to achieve long-term emissions reduction goals.

Emissions Sectors

The LGO inventory is organized into the following six sectors: Municipal Buildings, Other Municipal Facilities, Public Lighting, On-Road Vehicles, Off-Road Vehicles, and Process or Fugitive Emissions.

Municipal Buildings

The Municipal Buildings sector represents the energy consumption from all City-operated buildings. This sector analyzes emissions resulting from the consumption of electricity, natural gas, and heating fuel oil. Utility bill records were used to attribute emissions according to five department sub-sectors, including: administration, emergency services, libraries, recreation, and schools.

Other Municipal Facilities

In addition to the buildings analyzed in the Municipal Buildings sector, the City operates several other energy-consuming facilities. This sector includes fire pumps, traffic control boxes, and a miscellaneous category for facilities that cannot be specifically attributed to another sub-sector based on current utility data records. In future inventory updates, the collected activity data may provide additional detail that allows the miscellaneous category to be reallocated.

Public Lighting

The Public Lighting sector includes electricity consumption from City-operated streetlights, traffic lights, and park/recreational lighting.

On-Road Vehicles

This sector includes emissions from fuel consumption in City-operated on-road vehicles (e.g., police cruisers). Emissions were analyzed according to vehicle fuel type, including gasoline, diesel, and biodiesel. The City's fuel-tracking system also allows the data to be analyzed according to City department.

Off-Road Vehicles and Equipment

The Off-Road Vehicles and Equipment sector includes the fuel consumption from specialized equipment operated by City departments, such as tractors, generators, and aerial arm lifts. As with the On-Road Vehicles emissions, this sector was analyzed based on fuel type, including, gasoline, diesel, biodiesel, and liquefied petroleum gas (LPG).

Process and Fugitive Emissions

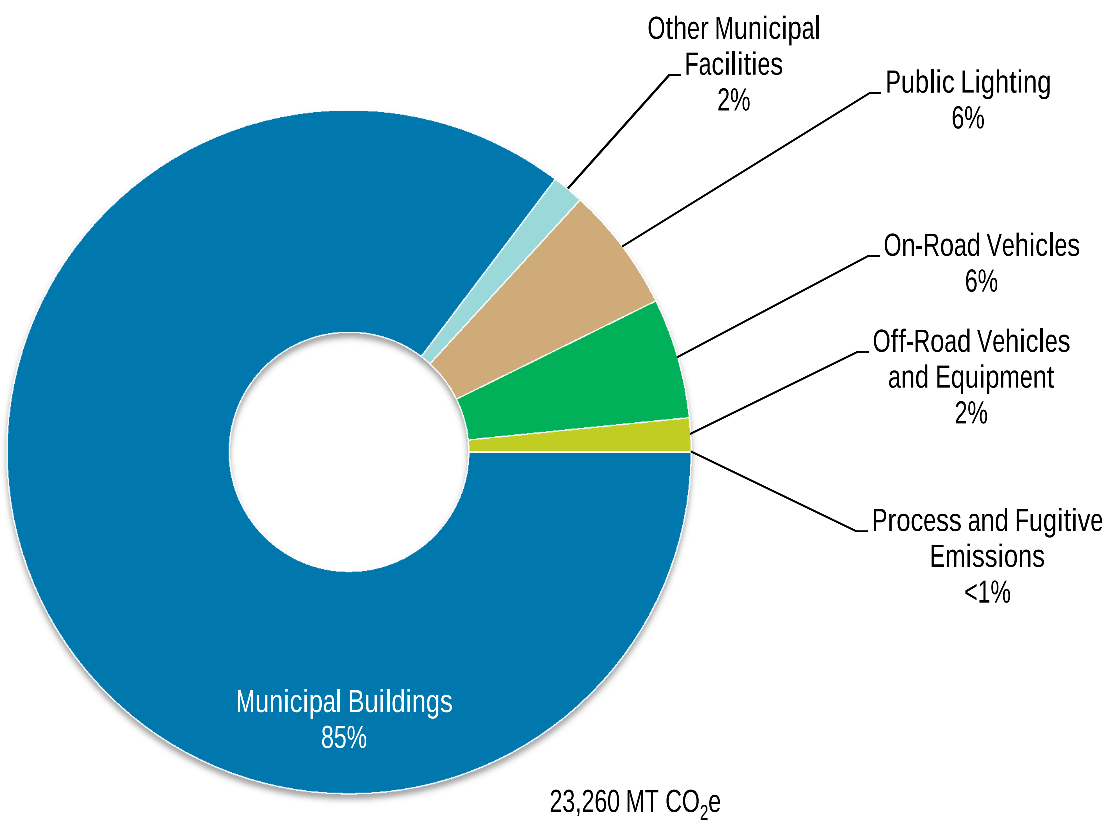
The Process and Fugitive Emissions sector represents emissions resulting from the use of refrigeration systems at the City's ice rinks. Information on emissions from refrigerants is sourced from contractors who maintain specific cooling systems. This category was not included in the community inventory as it was not feasible to access this information at the community-wide scale.

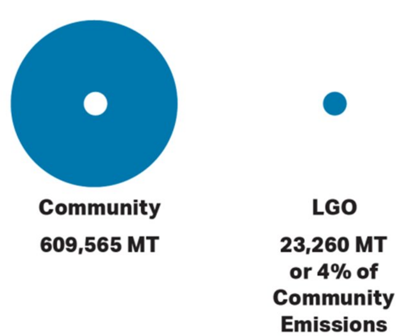
Base Year Inventory

City operations generated approximately 23,260 MT CO_2e in the 2014 base year, representing 4% of the total Community emissions. As shown in Figure 13 on the following page, the Municipal Buildings sector accounts for the overwhelming majority (i.e., 85%) of LGO emissions. The Public Lighting and On-Road Vehicles sectors each contribute approximately 6% of total emissions. The remaining emissions come from Off-Road Vehicles and Equipment, Other Municipal Facilities (e.g., fire pumps and traffic control boxes), and Process and Fugitive Emissions. Based on this inventory, the primary source of emissions from City operations is related to the provision of heat, lighting and equipment use in municipal buildings. This information can begin to inform the types of actions that would be most effective in reducing LGO emissions in the future.

The following pages provide greater detail on the distribution of emissions within each sector. Emissions are represented according to departmental sub-sectors, fuel-type, or both.

Figure 13 – Local Government Operations 2014 Base Year Greenhouse Gas Emissions Inventory

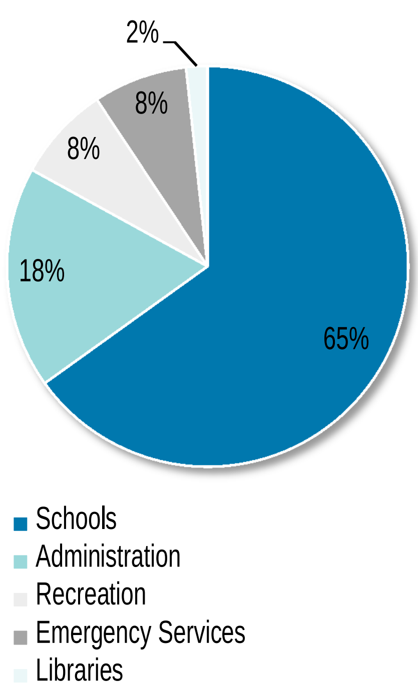




Municipal Building Emissions

Emissions from the Municipal Building sector account for 85% of total emissions and were further analyzed according to department categories to illustrate the primary contributors of emissions within the sector (Figure 14). The City's 11 school buildings comprise more than 1.25 million square feet of space, and generated the majority of building-related emissions (i.e., 65%). General administration buildings were the second highest contributor with 18% of sector emissions. This sub-sector includes more than 230,000 square feet of space in 10 City buildings, including City Hall, the Department of Public Works facility, and the Cross Street Senior Center. Recreation and Emergency Services buildings each contributed 8% to the sector total. The City's three libraries generated the remaining 2% of building emissions.

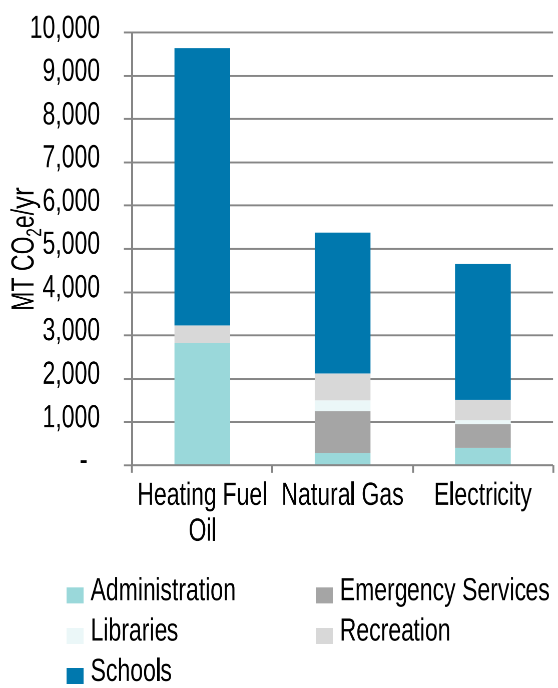
Figure 14 – Municipal Buildings Emissions by Sub-Sector



Building emissions can also be evaluated based on the type of energy used (Figure 15). Heating fuel oil generates nearly half of all building-related emissions. Natural gas and electricity each provide approximately one-quarter of sector emissions.

The distribution of emissions by fuel type can inform the future reduction strategy development process. For example, strategies that aim to increase the use of renewable energy within the electricity portfolio will only apply to 24% of building-related emissions. To achieve a meaningful reduction in emissions from this sector, additional strategies to reduce use of heating fuel oil would be needed to address the primary emissions source in the Municipal Buildings sector.

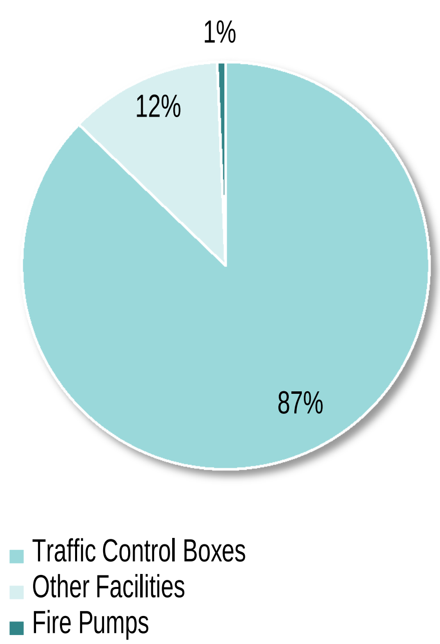
Figure 15 – Municipal Buildings Emissions by Energy Type



Other Municipal Facilities

Other Municipal Facilities account for 2% of the total LGO emissions. The City's 28 traffic control boxes are the primary emissions source in this sector, and contribute 87% of total sector emissions (Figure 16). Fire pumps contribute approximately 1% of sector emissions. The remaining 12% of emissions cannot be accurately classified into a specific subsector at this time. Changes to the City's utility data collection systems may support additional analysis in the future. All emissions from this sector are associated with electricity use.

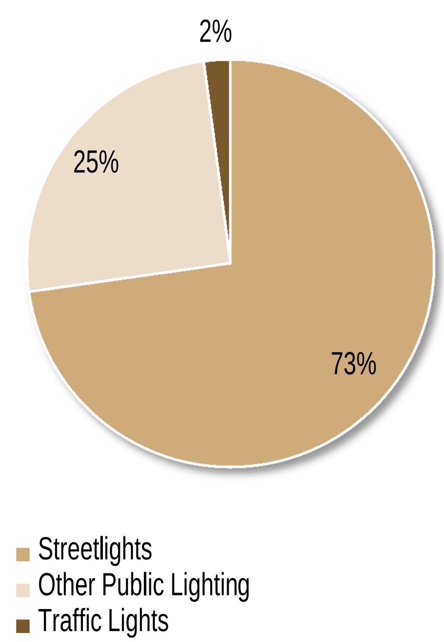
Figure 16 – Other Municipal Facilities Emissions by Sub-Sector



Public Lighting

The Public Lighting Sector accounts for 6% of total LGO emissions. The City operates more than 3,800 streetlights, which generate nearly 75% of emissions in the Public Lighting sector. Traffic lights contribute an additional 2% of sector total emissions (Figure 17). Utility data records identify 25 unique traffic light accounts in the city. The remaining 25% of emissions from this sector cannot be further classified into either the streetlights or traffic lights sub-sectors. However, the other public lighting sub-sector includes more than 1,000 decorative lights and building lighting, including outdoor security lights. As with the Other Municipal Facilities sector, future changes in utility data collection systems or technology may allow the City to further analyze the facility-specific end users in this sector. This deeper analysis would help support development of focused emissions reduction strategies by allowing the City to more accurately identify energy savings opportunities.

Figure 17 – Public Lighting Emissions by Sub-Sector

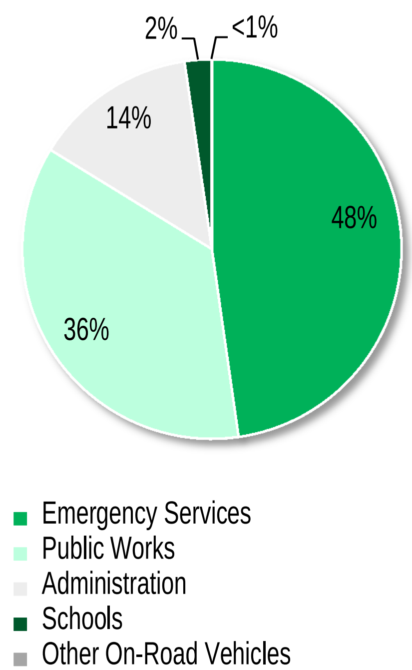


On-Road Vehicles

On-Road Vehicles contribute 6% of the total LGO emissions. The City's vehicle fleet contains nearly 240 vehicles whose operation results in the On-Road Vehicle sector emissions. Vehicle emissions were analyzed by City department as well as fuel type, as shown in

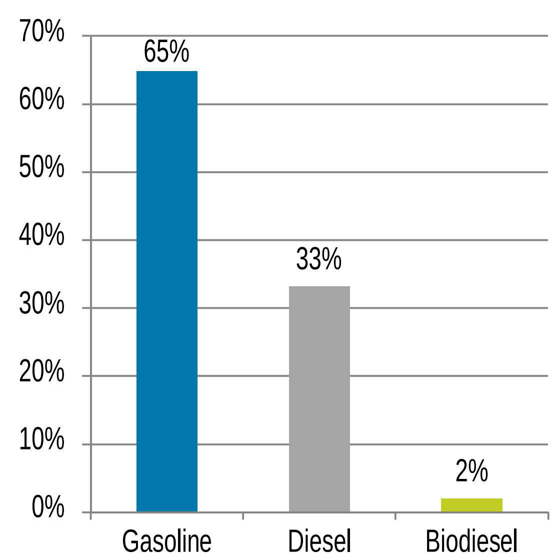
Figure 18 below. Emergency vehicles were the largest contributor, providing 48% of sector emissions, followed by Public Works vehicles with 36% of emissions. General administration vehicles provided another 14%, while the City's schools and other miscellaneous vehicles (i.e., insufficient data available to allocate vehicles to a specific department) contributed the remaining 2% of sector emissions.

Figure 18 – On-Road Vehicles Emissions by Sub-Sector



When analyzed by fuel type, gasoline vehicles generate nearly two-thirds of sector emissions (Figure 19). Diesel vehicles contribute one-third of emissions, and biodiesel vehicles provide the remaining 2%. Electricity emissions may be included in future inventory updates as the City started installing electric vehicle charging stations and added four electric vehicles to the City fleet in 2015.

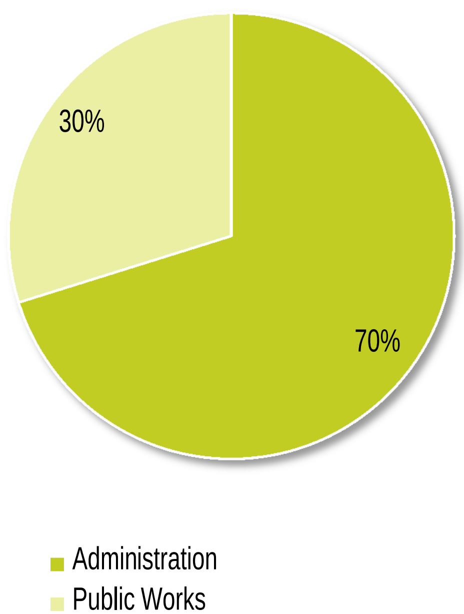
Figure 19 – On-Road Vehicles Emissions by Fuel Type



Off-Road Vehicles and Equipment

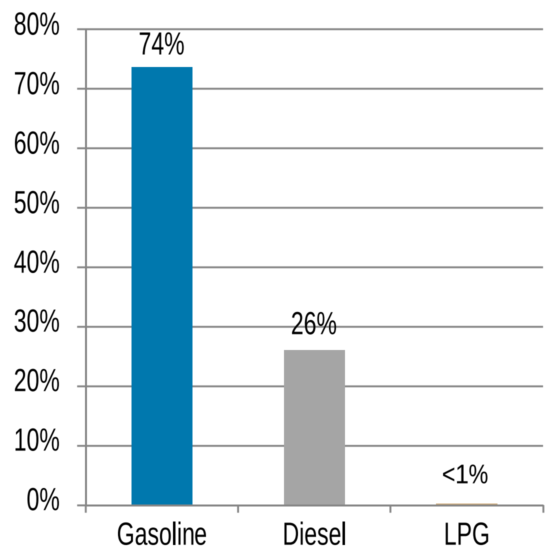
On-Road Vehicles contributed 2% of the total LGO emissions. The City operates nearly 40 pieces of off-road equipment within its vehicle fleet, including backhoes, sewer cleaners, front-loaders, aerial lifts, and snow blowers. Municipal off-road vehicle and equipment data was organized into two departmental sub-categories: Administration and Public Works (Figure 20). Approximately two-thirds of this sector's emissions originate from Administration uses, with the remaining one-third associated with Public Works activities.

Figure 20 – Off-Road Vehicles / Equipment Emissions by Sub-Sector



As with the On-Road Vehicles sector, the Off-Road Vehicles/Equipment sector was also analyzed by fuel type (Figure 21). The majority of emissions came from gasoline vehicles and equipment (i.e., 74%). Diesel vehicles and equipment contributed approximately one-quarter of sector emissions, with LPG uses accounting for the remainder. In 2015, the City began using a new piece of diesel-powered snow-melting equipment. In future inventory updates, diesel emissions may represent a greater share of the sector total.

Figure 21 – Off-Road Vehicles / Equipment Emissions by Fuel Type



Emissions Forecasts

As with the community inventory, municipal emissions are forecast for three future planning years (2020, 2035 and 2050) to estimate how LGO emissions will grow through the City's long-term target year of 2050. The forecast provides a near-, mid-, and long-term emissions estimates based on varying growth factors for each sector or sub-sector, including:

- municipal budget and operating forecasts,
- community population growth,
- new city park development,
- new city library construction, and
- acreage of urban infill development envisioned in the SomerVision comprehensive plan.

LGO emissions were forecast under a business-as-usual scenario, assuming that no emissions-reduction actions will be undertaken beyond those already in place in the base year. Under this BAU scenario, LGO emissions are forecast to grow approximately 31% from the 2014 base year through 2050.

In order to maintain consistency with the community emissions analysis, LGO emissions were also analyzed under an ABAU scenario that considers the impact of Massachusetts' RPS legislation. As with the community emissions, implementation of this policy will result in lower electricity-related emissions in the LGO inventory than would have occurred in its absence.

Refer to the supporting Technical Memorandum for further detail on how the LGO emissions growth assumptions were developed and applied to the base year inventory.

As shown in Table 2 on the following page, LGO emissions are forecast to grow from approximately 23,260 MT CO_2e in 2014 to 28,525 MT CO_2e in 2050. This represents 23% growth from the base year inventory, or approximately 0.6% growth per year.

Sector-level emissions are estimated to grow at varying rates. The Municipal Building and Public Lighting sectors are forecast to increase by approximately 24% each based on community population and employment growth estimates, which drive increased demand for municipal services. This demographic growth will lead to increased demands on government services, which is assumed to result in the need to build and operate additional municipal buildings and facilities and hire additional City staff. As with the community inventory forecasts, the long-term population and employment estimates were developed by the Boston Region MPO.

Further, the Public Lighting sector is also expected to grow based on estimates for new roadway construction and new park development, which will result in additional installations of street and traffic lights and outdoor recreational lighting. According to SomerVision, the City's long-range comprehensive plan, 15% of the City's land area is designated as "Areas to Transform". Much of this land area is currently in industrial use with a sparse roadway network. The emissions forecast assumes that long-term transformation of these areas will result in a denser network of local roads to accommodate future housing, employment, and retail uses, which will result in additional street light installations in this part of the city. However, through the recently initiated LED conversion program, it is hoped that this forecast increase in streetlight emissions will be offset through improved lighting efficiency.

The On-Road Vehicles and Off-Road Vehicles and Equipment sectors are forecast to grow by 14% and 9%, respectively, based on future fuel expenditure estimates from the City's budget analysis.

The Other Municipal Facilities sector (e.g., fire pumps and traffic control boxes) is forecast to increase by approximately 4% based on community population and employment growth estimates, which drive increased demand for municipal services.

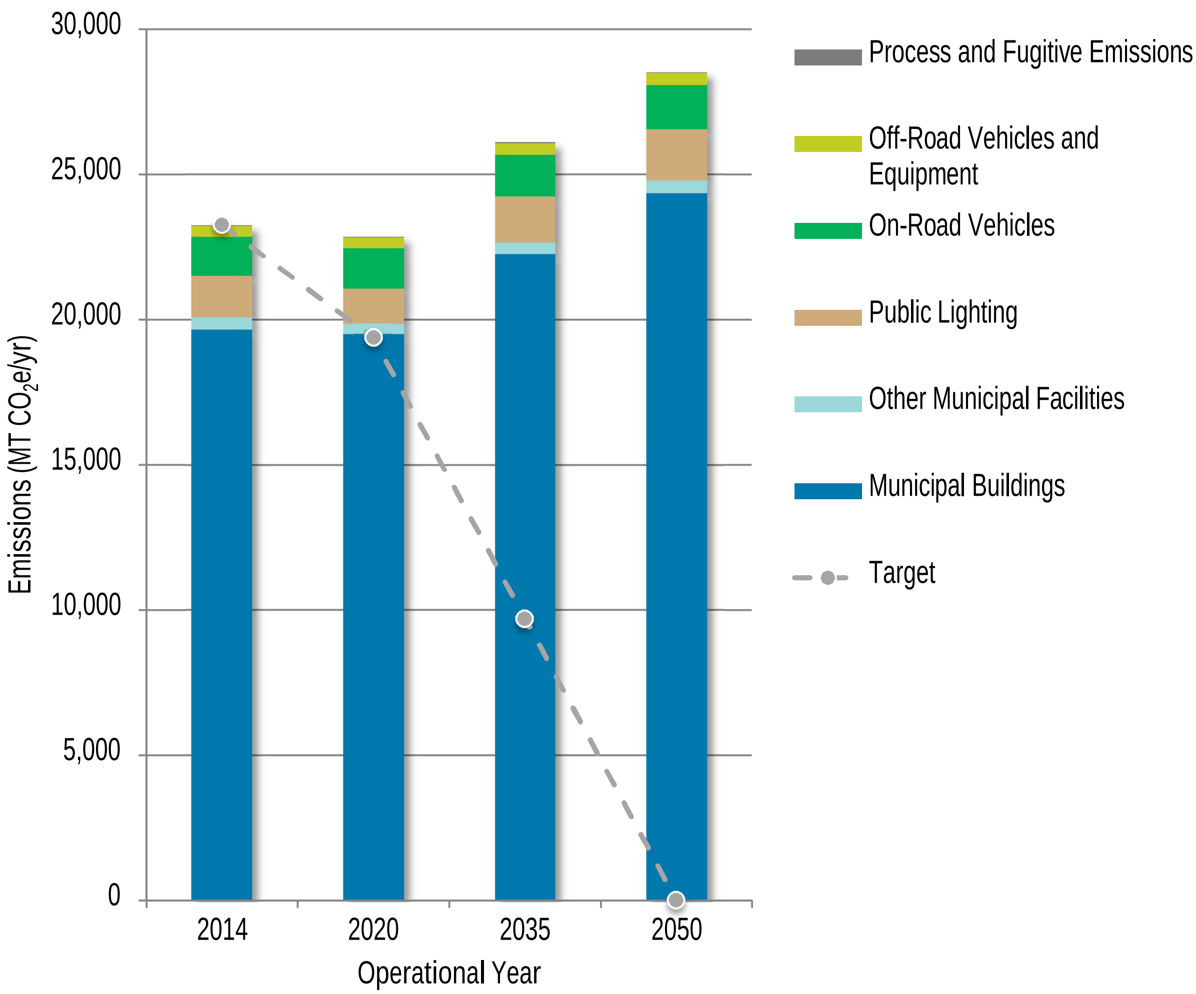
The Process and Fugitive Emissions sector was forecast to experience no change in emissions under the assumption that no additional municipal ice rinks would be constructed prior to 2050 and that the cooling systems of existing rinks would not change. Therefore, current emissions related to refrigerants would remain constant into the future.

Figure 22 illustrates emissions growth by sector for each of the planning years. It also overlays an emissions target trajectory consistent with the Mayor's long-term goal for zero-emissions by 2050. This target line shows what emissions levels would need to be in each planning year if a straight line was drawn from the 2014 base year emissions level to zero-emissions in 2050. Target achievement would require annual emissions reductions of approximately 665 MT CO_2e/yr from the base year, as opposed to the estimated emissions increase of 145 MT CO_2e/yr shown in the forecast table.

Table 2 – LGO Emissions Inventory and Forecasts

Sector	2014 (MT CO_2e)	2020 (MT CO_2e)	2035 (MT CO_2e)	2050 (MT CO_2e)
Municipal Buildings	19,670	19,510	22,260	24,365
Administration	*3,525*	*3,435*	*3,440*	*3,445*
Emergency Services	*1,495*	*1,425*	*1,580*	*1,760*
Libraries	*340*	*330*	*370*	*410*
Recreation	*1,510*	*1,770*	*2,930*	*3,260*
Schools	*12,800*	*12,550*	*13,940*	*15,490*
Other Municipal Facilities	415	340	395	430
Traffic Control Boxes	*360*	*295*	*340*	*375*
Fire Pumps	*5*	*5*	*5*	*5*
Other Facilities	*50*	*40*	*50*	*50*
Public Lighting	1,430	1,235	1,590	1,765
Streetlights	*1,040*	*855*	*975*	*1,085*
Traffic Lights	*30*	*25*	*30*	*30*
Other Public Lighting	*360*	*355*	*585*	*650*
On-Road Vehicles	1,340	1,370	1,440	1,525
Administration	*185*	*190*	*190*	*195*
Public Works	*485*	*500*	*540*	*590*
Emergency Services	*640*	*650*	*675*	*705*
Schools	*30*	*30*	*35*	*35*
Other Vehicles/Equipment	*<1*	*<1*	*<1*	*<1*
Off-Road Vehicles/Equipment	375	380	395	410
Administration	*265*	*265*	*265*	*265*
Public Works	*110*	*115*	*130*	*145*
Refrigerant Use	30	30	30	30
TOTAL	23,260	22,865	26,110	28,525

Figure 22 – LGO Emissions Forecasts (Adjusted Business-as-Usual)



LGO emissions are forecast to decrease between 2014 and 2020 before increasing again through 2050. This decrease is attributed to the emissions reductions associated with implementation of the RPS program. The relatively minor decrease in emissions from this statewide policy is forecast to be offset by LGO emissions growth factors after the 2020 planning year.

Priority Emissions Sources

As shown in this section, LGO emissions are primarily a result of energy consumption in City buildings and facilities. The sub-sector and fuel use data allow for further analysis, which begins to suggest the kind of near-term strategies or actions that would help set the City on a path towards achievement of its emissions targets shown in Figure 22. The box below outlines the path towards one potential reduction strategy based on analysis of the primary LGO emissions sources and their underlying activity data.

2014 MUNICIPAL BUILDING ENERGY USE

- 85% of total emissions

School energy use

- 55% of total emissions

Heating fuel use in schools

- 28% of total emissions

2014 PUBLIC LIGHTING ENERGY USE

- 6% of total emissions

Streetlights energy use

- 4% of total emissions

Strategies that focus on building energy conservation would specifically target the highest emissions sources in the inventory. These could include increasing thermal efficiency, lighting retrofits, and building systems maintenance and retro-commissioning, among other strategies. Based on the departmental sub-sector analysis, the City's schools are the largest contributor within the Municipal Buildings sector. An efficiency program targeting schools could affect 55% of total LGO emissions.

Similarly, within the schools sub-sector, heating fuel oil use is the largest emissions source, contributing nearly 30% of total LGO emissions. As shown in Figure 23, heating fuel oil consumption is also the largest source of municipal emissions across all sectors, suggesting a broad opportunity for emissions reductions across each City building type. This fuel use analysis, in combination with the other emissions inventory data, may be useful in helping to prioritize emission reduction actions.

Figure 23 – 2014 LGO Base Year Emissions by Energy Type