TOWN OF ACTON, MA

GREENHOUSE GAS INVENTORY

June 2019

Prepared for:

Town of Acton

Green Advisory Board

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Glossary

ABRSD	Acton Boxborough Regional School District
AWD	Acton Water District
BTU	British thermal units
CBECS	Commercial Building Energy Consumption Survey
CH_4	Methane
CO_2e	Carbon dioxide equivalent
EIA	Energy Information Administration
EOWLD	Executive Office of Workforce and Labor Development
EPA	Environmental Protection Agency
GHG	Greenhouse gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GWP	Global warming potential
kW	kilowatts
LGOP	Local Government Operations Protocol
MCF	Thousand cubic feet
MMBTU	One million British thermal units
MSW	Municipal solid waste
$MTCO_2e$	Metric tons of carbon dioxide equivalent
MWh	Megawatt-hours
N_2O	Nitrous oxide
RECS	Residential Energy Consumption Survey
VMT	Vehicle miles travelled
WWTF	Wastewater treatment facility

1. Executive Summary

1.1. Overview

This report presents the 2017 Greenhouse Gas Inventory for the Town of Acton in conjunction with the Town of Acton Green Advisory Board. The inventory addresses both community-wide emissions and municipal emissions, the latter of which are a subset of the community-wide inventory. GHG inventories are designed to help communities understand their sources of greenhouse gases and devise strategies for targeted emissions reductions.

This report contains the first greenhouse gas inventory conducted for the Town of Acton as part of their efforts toward establishing carbon neutrality. It can serve as an indicator of emissions contributions for the Town and be used in the future as a benchmarking tool for progress in the reduction of greenhouse gas emissions.

The inventory was conducted using established greenhouse gas accounting methodologies, including the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), U.S. Community Protocol (Community Protocol), and Local Government Operations Protocol (LGOP). 2017 was selected as the base year as it was the most recent year with complete data available. Stationary energy, transportation, and waste emissions are included, encompassing residential, commercial, industrial, and municipal operations.

1.2. Results

In total, the Town of Acton emitted 241,390 metric tons of carbon dioxide equivalent ($MTCO_2e$) in 2017, or 10.2 $MTCO_2e$ per capita. For regional comparison, the City of Cambridge emitted 13.8 $MTCO_2e$ per capita in 2012, and City of Somerville emitted 8.25 $MTCO_2e$ per capita in 2014, though these neighboring municipalities have different characteristics than the Town of Acton with respect to population density, transportation, and industry. The contributions by sector for Acton are illustrated in Figure 1. The transportation sector was the largest contributor, producing 51.3% of the emissions, followed by stationary energy with 45.4%.

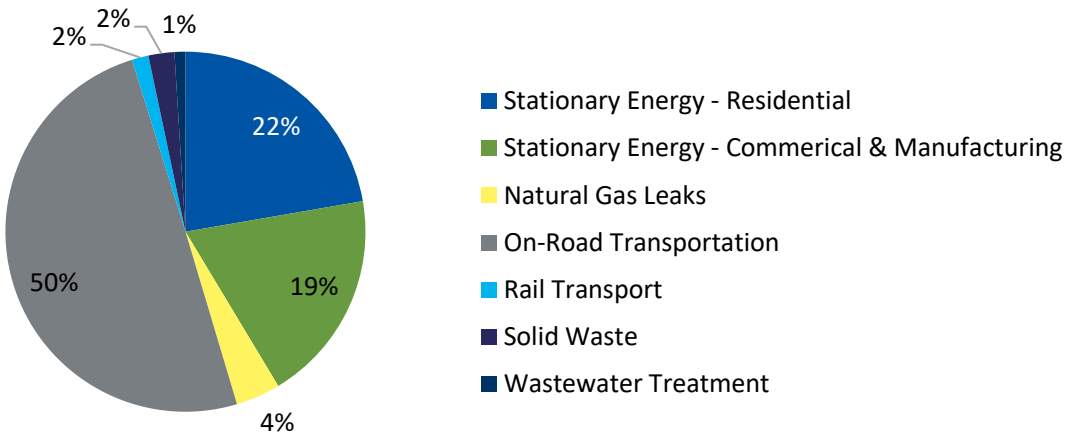

Figure 1. Total Community GHG Emissions by Source

Of the 241,390 total $MTCO_2e$ emitted community-wide by Acton in 2017, Acton's municipal operations released 12,722 $MTCO_2e$. In this inventory, municipal operations refers to Town of Acton property, the Acton-Boxborough Regional School District, and Acton Water District. This constitutes 5.3% of total Acton emissions. The largest sector source of municipal emissions is the Town's facilities and infrastructure, followed by emissions released by operation of the municipal on-road vehicle fleet.

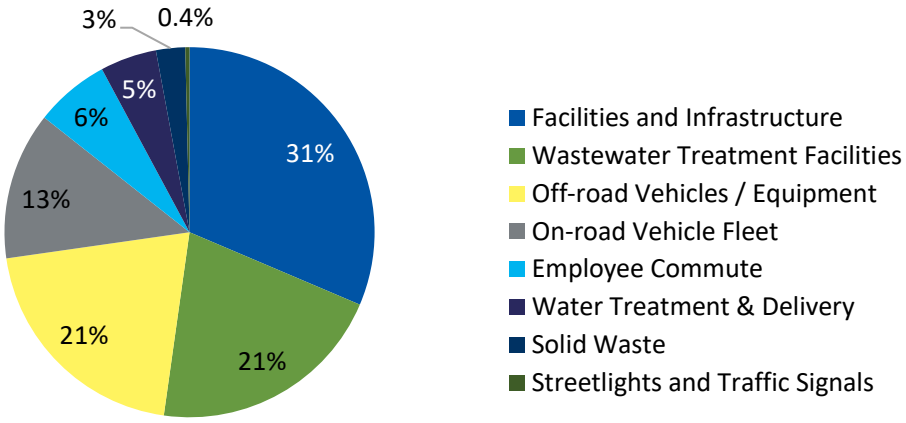

Figure 2. Total Municipal GHG Emissions by Source

1.3. Recommendations

To reduce greenhouse gas emissions and the carbon footprint of the Town of Acton, this report recommends assessing options in the highest community emission sectors as indicated by the community GHG inventory. Passenger vehicle travel and residential stationary energy use represent key target areas. Prioritized options include:

- Expansion of public transit or ride-sharing/carpooling opportunities to address transportation sector emissions,
- Encouragement of conversion of private vehicles to EV through expansion of EV charging stations throughout the Town,
- Further integration of renewable energy through program such as Acton Power Choice,
- Strategic electrification of stationary energy via the conversion of fuel oil heating systems to electric heating systems in residential and commercial buildings, and
- Pursuit of energy efficiency programs available via Mass Save to reduce energy consumption in both the residential and C&I sectors.

Other opportunities to reduce emissions include:

- Further assessment and repair of natural gas leaks,
- Potential expansion of centralized wastewater treatment in capital planning to encompass some households currently on septic systems,
- Increased commercial recycling to divert waste from landfill, and
- Electrification of the municipal vehicle fleet through the procurement of electric vehicles.

2. Introduction

2.1. What Are Greenhouse Gases?

Greenhouse gases (GHGs) are gases that contribute to the greenhouse effect by absorbing infrared radiation. Examples include carbon dioxide, methane, and chlorofluorocarbons. Six different GHGs are measured to determine emissions (Table 1) and each GHG traps heat in the atmosphere at different levels. The most significant GHG is carbon dioxide (CO_2) as it is more prevalent than other GHGs. Therefore, we measure total emissions based on how each GHG's heat trapping capacity compares to CO_2. Table 1 identifies the comparative warming of each gas to CO_2, also known as global warming potential (GWP). This enables the aggregation of the total amount of GHGs emitted into CO_2 equivalents (CO_2e). For example, one metric ton of methane released in the atmosphere would be reported as 28 metric tons of CO_2e. Communities and local governments release predominantly CO_2, methane, and nitrous oxide.

Table 1. Activities and Global Warming Potentials Associated with Greenhouse Gases (AR5)

Greenhouse Gas	Activities	Global Warming Potential (GWP)
Carbon dioxide (CO_2)	Burning fossil fuels	1
Methane (CH_4)	Burning fossil fuels, agricultural activities, landfill decomposition, wastewater treatment practices	28
Nitrous oxide (N_2O)	Burning fossil fuels, agricultural activities, industrial activities, landfill decomposition, wastewater treatment practices	265
Perfluorocarbons	Electronics industry	6,630 – 23,500
Hydrofluorocarbons	Air conditioning and refrigeration	116 – 12,400
Sulphur hexafluoride	Switchgear at power installations	23,500

2.2. Purpose

With guidance from the Town of Acton Green Advisory Board, the Town decided to undertake a greenhouse gas inventory as a step toward a Town of Acton Carbon Neutrality Initiative, through which the Town can join neighboring municipalities in efforts to reduce greenhouse gases and address the causes and impacts of climate change. The Acton Carbon Neutrality Initiative's goal is to measure GHG emissions to provide areas of focus to reduce future GHG emissions, further accelerate the Town's progress towards sustainability, and demonstrate regional leadership on climate change. Sustainability initiatives already undertaken in Acton include qualifying as a Massachusetts Green Community in 2010, establishment of the Acton Power Choice program, the development of a municipal solar farm, and a detailed measurement of methane leaks throughout the Town in 2017. This greenhouse gas inventory represents the next phase of the Town's effort in establishing carbon neutrality.

This inventory can serve as an indicator of emissions contributions for the Town and be used in the future as a benchmarking tool for progress in emissions reductions of future greenhouse gas emissions. This GHG inventory can be utilized to build upon, expand, and update municipal and community efforts, driving the pace of Acton's GHG reductions by identifying the most effective next steps to reduce Acton's carbon footprint. These efforts are critical if Acton is to meet the Massachusetts Global Warming Solutions Act's goal of a reduction of 25% below 1990 GHG emission levels 2020, and an 80% reduction by 2050.

2.3. Background on GHG Inventories

GHG Inventories can be conducted at both the community and municipal levels. While community inventories cast a wider net and capture all activities within scope of a community, municipal inventories are designed to specifically assess local government functions. Thus, municipal inventories are a subset of community inventories to help local governments decrease the environmental impacts of their operations. Elements captured by a GHG inventory fall into one of three categories:

1. ***Stationary energy***, or emissions associated with building energy consumption,
2. ***Transportation,*** or emissions associated with vehicles, which may include road, rail, air, and water travel, and
3. ***Waste,*** or emissions associated with solid waste management and wastewater treatment.

Within these categories, emissions sources can be further divided into different scopes. Scope 1 consists of direct emissions from owned or controlled sources, Scope 2 includes indirect emissions from purchased energy, and Scope 3 includes other indirect emissions.

A selection of GHG inventory protocols have been established to ensure consistent and transparent measurement and reporting of emissions. The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) was established by the World Resources Institute, C40 Cities, and ICLEI. It can be applied internationally and incorporates feedback from a series of global public comments and pilot tests. Additionally, the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (Community Protocol) provides guidance more specific to U.S. applications, and the Local Government Operations Protocol (LGOP) provides a methodology for developing municipal-level GHG inventories.

2.4. Acton Attributes and Inventory Scope

The Town of Acton is a municipality in Massachusetts incorporated in 1735. Located in Middlesex County, the Town occupies 20.3 square miles approximately 21 miles northwest of Boston, MA. In 2017, it had a population of 23,777.

The inventory includes:

1. Town of Acton Municipal Services
2. Acton Water District
3. Acton-Boxborough Regional School District

4. Commercial & Industrial Businesses
5. Residences

Acton schools are regionalized as part of the Acton-Boxborough Regional School District (ABRSD). The decision was made to attribute ABRSD data in this inventory to the Town of Acton, although a portion of the students served reside in Boxborough.

Sectors addressed by the analysis include:

1. Electricity
2. Stationary Combustion of Fossil Fuels
3. Transportation Fuels
4. Wastewater Treatment
5. Solid Waste Disposal and Recycling
6. Natural Gas Fugitive Emissions
7. Carbon Sequestration from Conservation Land

Items 1-6 are included in the GHG inventory. While carbon sequestration is an element not formally included in GHG inventories, an estimate of the benefits from conservation land under the Town's ownership and protection is included in this report.

3. Methodology

3.1. Community Inventory

The community inventory for the Town of Acton was produced following the GCP and Community Protocol. Emissions factors for sources were derived from the U.S. EPA's Emission Factors for Greenhouse Gas Inventories (2015), and the regional EPA eGRID factor for the NEWE New England Region for 2016. A description of the data sources and methodology for each source follows.

Stationary Energy

Stationary energy refers to the energy consumed by buildings in Acton. This takes the form of electricity, natural gas, and fuel oil for residential, commercial & institutional, and manufacturing facilities. In general, emissions are calculated by multiplying the quantity of fuel consumed or energy used by the appropriate emissions factor for that fuel. Electricity and natural gas are derived from data supplied by the utilities, while fuel oil is calculated using the assessor's database and published consumption estimates.

Electricity

Electricity is supplied to Acton by Eversource in conjunction with Acton Power Choice (APC). Acton Power Choice is an opt-out program designed to incorporate more renewable energy into the Acton electricity supply. The program has two levels of offerings: Power Choice Standard and Power Choice Green. Power Choice Standard, the default offering, includes 5% renewables from MA Class I RECs, in addition to any renewables included in the grid resource mix per Massachusetts requirements. Power

Choice Green is a 100% renewable energy option which provides customers with 100% renewable energy generated in New England. Data on the number of accounts subscribing to each option was obtained from Dynegy, the program administrator.

Table 2. Number of Acton Accounts Per Electricity Supply Option

Electricity Option	Residential	Business
Eversource Standard	521	20
APC Standard	6,968	832
APC Green	164	3
Total	7,653	855

Emissions for electricity are based on the eGRID 2016 emissions factor for the NPCC New England NEWE sub-region. The APC emissions factors account for the additional renewable energy incorporated into the resource mix.

Natural Gas

Natural gas data was provided by a Town of Acton contact and included aggregated natural gas consumption for the commercial and residential sectors, and distinguished between heat and non-heat applications.

The inventory also takes into account natural gas emissions related to fugitive emissions from gas leaks. The Town of Acton commissioned a gas leak study in 2017 (Town of Acton Methane Survey 2017), the results of which were incorporated into this inventory report. Further detail on the gas leak study and results is included in the results section.

Fuel Oil

Residential fuel oil consumption was determined using assessor's data in conjunction with the US Census Bureau American Community Survey and EIA Residential Energy Consumption Survey (RECS). Housing units were divided between single-family residences and condos, and the RECS data on average fuel oil consumption was applied. Total residential fuel oil consumption was estimated by multiplying the fuel oil consumption per housing type by the percentage of homes of each type with fuel oil heating per the assessor's database.

Commercial, industrial, and manufacturing fuel oil consumption was estimated on a per-employee basis. The EIA Commercial Building Energy Consumption (CBECS) and Manufacturing Building Energy Consumption (MBECS) surveys provide average energy consumption per employee. This, in conjunction with MA Executive Office of Labor and Workforce Development (EOWLD) Employment and Wages Survey, which provides the number of employees and establishments by industry, were used to estimate fuel oil consumption.

Transportation

Transportation emissions include emissions from on-road and rail transportation.

On-road transportation includes estimated emissions for personal and commercial vehicles traveling to, from, and within the Town of Acton. Quarterly vehicle miles travelled (VMT) for the Town of Acton were obtained from the 2014 MAPC Massachusetts, the most recent report of its kind (Table 3). The vehicle distribution included in the Community Protocol was used to determine fuel use and emissions associated with this total VMT value. Thus, transportation emissions are modeled estimates based on the most recently available VMT data.

Table 3. 2014 Vehicles Miles Traveled for Acton, MA

Quarter	Passenger VMT	Commercial VMT	Total VMT
Q1	46,465,430	2,927,363	49,392,793
Q2	46,724,298	2,976,133	49,700,431
Q3	47,736,916	3,044,313	50,781,229
Q4	48,289,536	3,019,551	51,309,087
Total	189,216,181	11,967,360	**201,183,540**

The MBTA Commuter Rail (Fitchburg Line) passes through Acton. Thus, rail transportation emissions account for an allocation of emissions associated with trains passing through Acton. This allocation was performed based upon the length of track that passes through Acton, the number of trains per day, and diesel fuel economy of the commuter rail. Fuel economy was calculated using total annual system miles and total annual fuel consumption.

Off-road transportation consists of farm and construction equipment and can be calculated using the EPA NONROAD emissions model. However, it is not included in the community inventory as it was deemed negligible. Water transport and aviation are excluded from this inventory as neither apply to the Town of Acton.

Waste and Water

Solid Waste Disposal

Solid waste disposal accounts for municipal solid waste (MSW) generated by town residents and commercial businesses. Two collection methods are utilized in the Town of Acton: pay as you throw (PAYT) and independent haulers.

In the PAYT program, PAYT participants haul their own, predominantly household, waste and recycling to the Acton Transfer Station. Participants either pay an annual fee to use the transfer station or may pay per trip. Non-recyclable waste brought to the transfer station is ultimately incinerated at a North Andover or Millbury waste-to-energy facility. Tonnage reports from the Acton DPW were used to calculate emissions from waste from the PAYT program.

Instead of utilizing the PAYT program, some residents and commercial businesses contract independent haulers to manage waste. Independent hauler reports provided to the DPW indicated the quantity of waste generated, but not disposal method. In the Commonwealth of Massachusetts, approximately one-third of waste is incinerated. Independent hauler waste emissions were divided between incineration,

landfill with gas collection, and landfill without gas collection, and the emissions were calculated accordingly. The processing method for waste is heavily time and market dependent as it varies based on current disposal costs and availability.

Incineration emissions were calculated by attributing GHG emissions reported to EPA from the Wheelabrator Saugus incineration plant, as a proxy for the Millbury and North Andover Wheelabrator facilities that process Acton waste, based on the amount of Acton waste incinerated. Landfill waste emissions were calculated using Community Protocol SW 4.1, with a landfill gas collection rate of 0% for landfill without capture and 75% for landfills with capture, based on protocol guidelines.

Wastewater Treatment

Wastewater generated by residents and businesses in the Town of Acton is processed in one of three ways: at a central wastewater treatment facility, in privately-owned package/cluster wastewater treatment facilities, or via septic systems.

Acton is primarily served by septic systems, as 80% of parcels utilize them for wastewater treatment. 10% of parcels are served by one of ten package/cluster facilities, primarily associated with condominium buildings. The final 10% of Town of Acton parcels are served by the Acton Middle Fort Pond Brook Wastewater Treatment Facility, which treats wastewater via an aerobic sequencing batch reactor (SBR), filtration, and UV disinfection.

Both the GPC and Community Protocol provide methodologies for the calculation of methane and nitrous oxide emissions associated with wastewater treatment. The Community Protocol methodology was used in this report. All calculations are estimates based on population served by each treatment method. As the WWTF and cluster facilities treat waste through aerobic processes, methane is not generated as it would be using anaerobic processes. WWTF emissions are calculated using Community Protocol WW.8 and WW.12, while cluster system emissions are calculated with WW.10. Septic system emissions consist of fugitive methane emissions and were calculated using the Community Protocol WW.11.b.

The GPC provides guidelines for calculation of CH_4 and N_2O emissions associated with wastewater treatment. However, CH_4 emissions for septic systems are estimated using the Community Protocol and are based on the population served by septic systems.

Table 4. Types of Emissions Generated by Wastewater Treatment Methods

Source	Population Served	Methane (CH_4)	Nitrous Oxide (N_2O)
WWTF	2,378	N	Y
Cluster Facilities	2,378	N	Y
Septic	19,022	Y	N

3.2. Municipal Inventory

The Acton Municipal GHG Inventory followed the recommended guidance in ICLEI's *Local Government Operations Protocol: For the quantification and reporting of greenhouse gas emissions inventories* (Government Protocol)[1]. This protocol provides recommended and alternative methods for calculating GHG emissions released as a result of energy use from facilities, vehicles and equipment owned and operated by the Town of Acton, water and wastewater treatment, solid waste deposition, and from fuel used for employee commute during 2017.

Stationary Energy

Facilities and Infrastructure

The Facilities and Infrastructure sector comprises emissions that result from energy consumption in buildings that are owned and operated by the Town of Acton. Emissions were calculated based on the town's electricity, natural gas, and fuel oil use, following the methodologies in the Government Protocol. A summary of the results and methodologies used for 2017 are provided in Table 5**.**

Table 5. Summary of Municipal Facilities and Infrastructure Sector Data and Methodologies 2017

Department	Source	Methodology	Activity	Units	$MTCO_2e$
Administrative	Electricity	6.2.1	160,894	kWh	41
Fire/Police	Electricity	6.2.1	477,126	kWh	122
Public Works	Electricity	6.2.1	100,398	kWh	26
Recreation	Electricity	6.2.1	79,818	kWh	20
Cemetery	Electricity	6.2.1	9,065	kWh	2
Libraries	Electricity	6.2.1	500,568	kWh	128
Schools	Electricity	6.2.1	5,594,536	kWh	1,430
Administrative	Natural Gas	6.1.1	10,266	therms	55
Fire/Police	Natural Gas	6.1.1	30,894	therms	164
Public Works	Natural Gas	6.1.1	7,893	therms	42
Recreation	Natural Gas	6.1.1	2,333	therms	12
Cemetery	Natural Gas	6.1.1	-	therms	-
Libraries	Natural Gas	6.1.1	14,434	therms	77
Schools	Natural Gas	6.1.1	342,968	therms	1,822
Administrative	Fuel Oil No.2	6.1.1	2,168	gal	22
Cemetery	Fuel Oil No.2	6.1.1	1,861	gal	19
Libraries	Fuel Oil No.2	6.1.1	1,182	gal	12

Electricity and natural gas data was obtained from Andrea Ristine, Town of Acton Municipal Properties Superintendent, and Kate Crosby, ABRSD Energy Manager. Electricity emissions were calculated using a

[1] Available at: http://icleiusa.org/ghg-protocols/

regional EPA eGRID factor for the NEWE New England Region for 2016[2]. Natural gas emission factors from EPA Mandatory Reporting Rule[3], published in November 2015, and last updated in March 2018, were used to calculate natural gas emissions for both 2016 and 2008.

Fuel oil activity data for municipally owned and operated buildings was obtained from Andrea Ristine, who extracted it from Portfolio Manager. Emission factors for fuel oil were obtained from the EPA Mandatory Reporting Rule, published in November 2015 and last updated in March 2018.

Streetlights and Traffic Signals

The Streetlights and Traffic Signals sector comprises emissions that result from electricity used to power streetlights and traffic signals across all town departments that are owned and operated by the Town of Acton. Emissions were calculated based off the town's electricity use in streetlights and traffic signals, following the methodologies in the Government Protocol. A summary of the results and methodologies used for 2017 are provided in Table 6**.**

Table 6. Summary of Municipal Streetlights and Traffic Signals Sector Data and Methodologies 2017

Department	Source	Methodology	Activity	Units	$MTCO_2e$
Streetlights/Traffic Signal	Electricity	6.2.1	184,304	kWh	47

Electricity use from streetlights and traffic signals was obtained from data the Town extracted from Portfolio Manager. Emissions were calculated using a regional EPA eGRID factor for the NEWE New England Region for 2016[4].

Transportation

Vehicle Fleet

The Vehicle Fleet sector comprises emissions that result from fuel consumption by on-road and off-road vehicles that are owned and operated by the Town of Acton. Emissions were calculated based off municipal fuel use data provided by the Town and extracted from Portfolio Manager and separately provided fuel usage for the school bus fleet, following the methodologies in the Government Protocol. A summary of the results and methodologies used for 2017 are provided in Table 7**.**

Table 7. Summary of Municipal Vehicle Fleet Sector Data and Methodologies 2017

Department	Source	Methodology	Activity	Units	$MTCO_2e$
Light Trucks	Gasoline	7.1.1	34,264	gal	302
Passenger Cars	Gasoline	7.1.1	37,207	gal	328
Heavy Trucks	Diesel	7.1.1	98,195	gal	275

[2] Available at: https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf
[3] Available at: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf
[4] Available at: https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf

Light Trucks	Diesel	7.1.1	813	gal	8
School Buses	Diesel	7.1.1	71,242	gal	728
Agricultural Equip.	Gasoline	7.1.1	-	gal	-
Agricultural Equip.	Diesel	7.1.1	4,223	gal	44
Construction Equip.	Gasoline	7.1.1	195,091	gal	1,727
Construction Equip.	Diesel	7.1.1	81,569	gal	840

To estimate fuel use by government owned and operated vehicles, VMT (by fuel and vehicle type) was divided by fuel efficiencies obtained from the U.S. EPA's Emission Factors for Greenhouse Gas Inventories last published in November 2015 and updated in March 2018. To estimate emissions from carbon dioxide, total gasoline and diesel use was multiplied by carbon dioxide emission factors obtained from the U.S. EPA's Emission Factors for Greenhouse Gas Inventories last published in November 2015 and updated in March 2018.

Employee Commute

The Employee Commute sector comprises emissions that result from fuel consumption by vehicles that are owned and operated by employees at the Town of Acton and used to get to-and-from work. A summary of the results and methodologies used for 2017 are provided in Table 8**.**

Table 8. Summary of Municipal Employee Commute Sector Data and Methodologies 2017

Department	Source	Methodology	Activity	Units	$MTCO_2e$
Light Trucks	Gasoline	N/A	447,965	VMT	230
Passenger Cars	Gasoline	N/A	837,861	VMT	316
Heavy Trucks	Diesel	N/A	74,661	VMT	272
Light Trucks	Diesel	N/A	17,974	VMT	10
Passenger Cars	Diesel	N/A	4,148	VMT	2

To estimate emissions from employee commute, the Town provided a set of anonymized employee lists containing each full-time and part-time employee's home zip code. VMT travelled by each employee was estimated using one-way distance to work obtained from Google Maps and then doubled to reflect the commute back home. It was assumed that full time employees worked 5 days per week for 47 weeks per year. Part time employees worked 3 days per week for 49 weeks per year.

Total VMT was assumed to have been generated by diesel and gasoline vehicles according to national averages for on-road vehicles that consume these fuels as provided by the US Community Protocol. Similarly, the amounts of each type of vehicle (heavy duty, light duty, passenger vehicles) were assumed to conform to national averages as provided by the US Community Protocol. VMT by fuel type and vehicle type was then used to calculate emissions from methane and nitrous oxide. Methane and

nitrous oxide emission factors for each fuel were obtained from the U.S. EPA's Emission Factors for Greenhouse Gas Inventories[5] last published in November 2015 and updated in March 2018.

Waste and Water

Solid Waste

The Solid Waste sector comprises methane emissions that result from the decomposition of materials deposited in a landfill that are generated at government owned and operated facilities in the GHG inventory year. While these emissions occur over time, and in landfills outside of the Town's jurisdictional boundary, they are attributed to the Town's government operations for the year in which the waste was generated. Waste sent to landfills was estimated using total square footage of municipal buildings provided by the Town and an average waste generation rate per square foot. Emissions were calculated using methodologies adapted from the Government Protocol. A summary of the results and methodologies used for 2017 are provided in Table 9**.**

Table 9. Summary of Waste Sector Data and Methodologies 2017

Subsector	Source	Methodology	Activity	Units	$MTCO_2e$
Municipal Solid Waste	Landfill Waste	ARB Landfill Tool v1.3	698	Tons	324
Alternate Daily Cover	Landfill Waste	ARB Landfill Tool v1.3	2	Tons	0

Yearly waste deposition from Acton's municipal facilities was estimated using total square footage of building area and average waste generation rates per square foot. Total government owned and operated building area in 2017 was provided by the Town of Acton. Waste generation factors were obtained from CalRecycle's Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry Groups[6]. All of The Town of Acton's building square footage was assumed to be "large office space" as defined in the CalRecycle report. This study also provided a characterization for the types and quantities of different materials present in waste deposited by office spaces. Waste from school data was also captured, using estimates based on ABRSD square footage and waste generation factors and diversion rates associated with school facilities. Emissions were determined using emission factors by waste type obtained from the California Air Resources Board's Landfill Tool v1.3[7] and methodologies adapted from the Government Protocol.

Alternative daily cover (ADC), material laid on top of landfilled waste to control odors, vectors, fires, litter and scavenging, was estimated using Massachusetts state averages for ratios of ADC/MSW calculated from MassDEP's 2011 Solid Waste Master Plan[8]. In Massachusetts, ADC is primarily contaminated soils, auto shredder residue, bottom ash and other materials. Emissions from ADC were

[5] Available at: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf
[6] Available at: https://www2.calrecycle.ca.gov/Publications/Details/1184
[7] Available at: https://www.arb.ca.gov/cc/protocols/localgov/pubs/landfill_emissions_tool_v1_3_2011-11-14.xls
[8] Available at: https://www.mass.gov/files/documents/2016/08/rr/11swdata.pdf

determined using emission factors from the California Air Resources Board's Landfill Tool v1.3[9] and methodologies adapted from the Government Protocol.

Wastewater Treatment

The Wastewater Treatment sector comprises emissions that result from electricity and fuel oil that was used to treat and convey wastewater during the inventory year, as well as the process and fugitive emissions that result from the treatment of organic materials in the wastewater.

Electricity use in the Wastewater Treatment sector, including both treatment and conveyance, was obtained from the Town via Portfolio Manager. Emissions were calculated using a regional EPA eGRID factor for the NEWE New England Region for 2016[10].

Fuel oil activity data for municipally owned and operated buildings was obtained from the Town via Portfolio Manager. Emission factors for fuel oil were obtained from the EPA Mandatory Reporting Rule, published in November 2015 and last updated in March 2018.

Process and fugitive emissions were estimated at the community-level based on per capita emissions rates contained within the US Community Protocol. A summary of the results and methodologies used for 2017 are provided in Table 10.

Table 10. Summary of Wastewater Treatment Sector Data and Methodologies 2017

Department	Source	MMBTU	Activity	Units	$MTCO_2e$
Public Works	Electricity	2,690	788,915	kWh	253
Public Works	Fuel Oil No.2	299	2,168	gal	22
Public Works	Wastewater Process and Fugitive	-	-	-	2,365

Process and fugitive emissions from wastewater treatment were calculated using population estimates for 2017 for the entire Town of Acton and standard methodologies in the Government Protocol. Since the Town owns and operates its own wastewater treatment facility (WWTF), all associated process and fugitive emissions at the WWTF are included in the municipal GHG inventory.

Water Treatment and Delivery

The Water Treatment and Delivery sector comprises emissions that result from energy consumption in facilities related to water treatment, well water extraction, pumping stations, and other related facilities that are considered part of the Acton Water District (AWD). The Acton Water District is a municipal entity separate from the Town of Acton. Emissions were calculated based on activity data of the town's electricity, natural gas, and propane use, following the methodologies in the Government Protocol. A summary of the results and methodologies used for 2016 are provided in Table 11.

[9] Available at: https://www.arb.ca.gov/cc/protocols/localgov/pubs/landfill_emissions_tool_v1_3_2011-11-14.xls

[10] Available at: https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf

Table 11. Summary of Water Treatment and Delivery Sector Data and Methodologies 2017

Department	Source	Methodology	Activity	Units	$MTCO_2e$
Acton Water District	Electricity	6.2.1	2,086,846	kWh	534
Acton Water District	Natural Gas	6.1.1	27,597	therms	93

Electricity use from water treatment and delivery facilities was obtained from the Acton Water District. Emissions were calculated using a regional EPA eGRID factor for the NEWE New England Region for 2016[11].

4. Community Inventory Results

4.1. Summary

In total, the baseline 2017 emissions for the Town of Acton are 241,390 $MTCO_2eq$. As shown in Figure 3, the transportation sector contributes the majority of emissions, followed by stationary energy and waste. This is also summarized in Table 12. With respect to more granular sources, on-road transportation was the single largest contributor at 50% of emissions, followed by residential energy consumption at 22%.

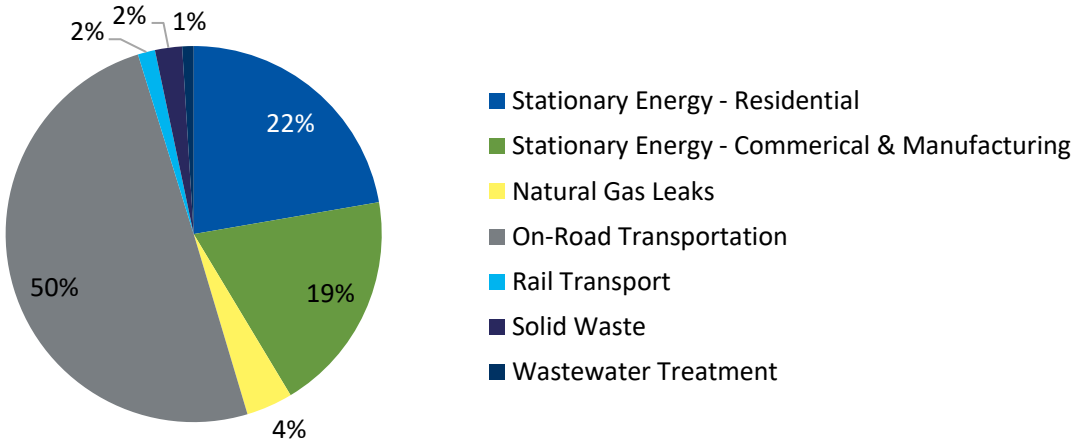

Figure 3. Total Community GHG Emissions by Source

Table 12. Total Community GHG Emissions Summary

Fuel Type	Emissions (MTCO2e)	Percentage
Stationary	109,541	45.4%
Transportation	123,866	51.3%
Waste	7,982	3.3%

[11] Available at: https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf

Total	241,390	100%

4.2. Stationary Energy

Table 13 provides a summary of stationary energy sources used in the Town. Stationary energy consumption produced a total of 109,541 $MTCO_2e$, illustrated in Figure 4.

Table 13. Community Stationary Energy Sources by Sector

Source	Electricity (GWh)	Fuel Oil (MMBTU)	Natural Gas (MMBTU)	Emissions (MTCO2e)
C&I Sector	89.25	77,388	347,628	46,094
Residential	65.91	214,003	415,458	53,796
Total	155.2	291,391	763,086	99,890

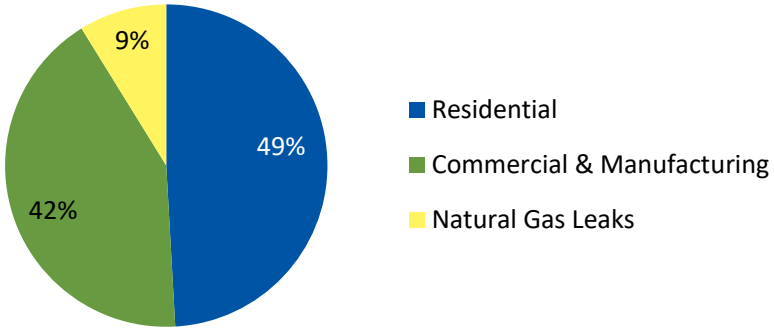

Figure 4. Community Stationary Energy GHG Emissions Contributions by Sector

Residential energy consumption constitutes the greatest proportion of stationary energy consumption. However, the contributions of fugitive natural gas are notable, at 9% of total stationary emissions. When assessing by fuel type (Figure 5), these gas leak contributions are equivalent to nearly half of the fuel oil emissions contributions and bring the total natural gas contributions to 45%.

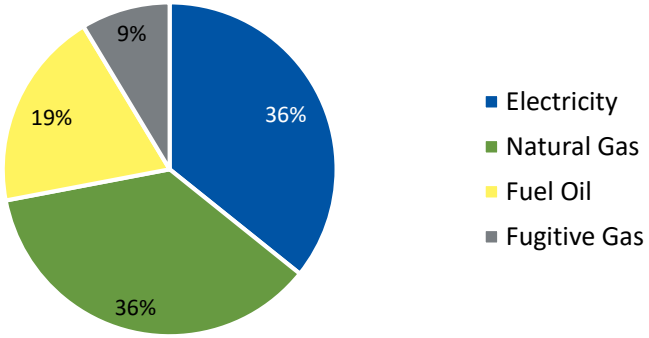

Figure 5. Community Stationary Energy GHG Emissions Contributions by Fuel Type

Figure 6 illustrates the composition of emissions for each building sector. Residential emissions are greater than the commercial and non-residential sector, and natural gas is the largest contributor in the residential sector. In the non-residential sector, however, electricity is the largest producer of emissions.

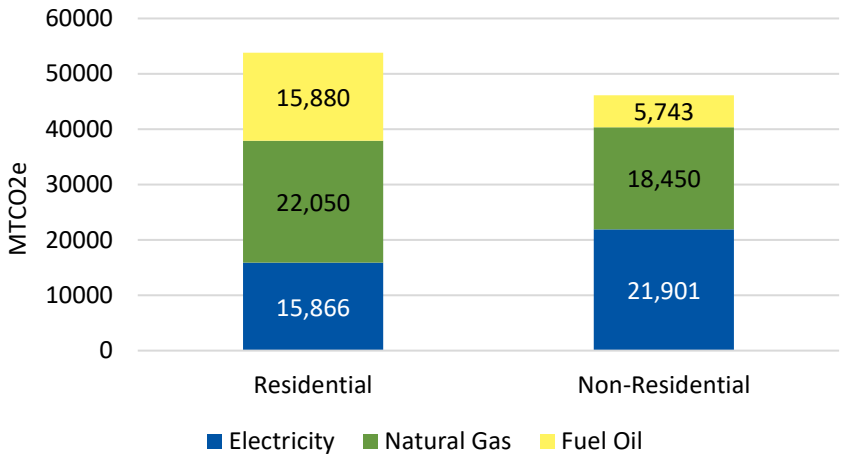

Figure 6. Community Stationary Energy GHG Emissions Contributions Per Building Sector

Electricity

An analysis was performed to evaluate the impact of Acton Power Choice on emissions related to electricity. The utilization of the 5% additional renewable energy option in the Acton Power Choice Standard and 100% renewable energy option in Acton Power Choice Green has reduced electricity emissions in Acton. When compared to the emissions factors for the standard electric grid mix, Acton Power Choice enrollment has decreased electricity's contributions to stationary energy emissions by 2%.

Natural Gas Leaks (Fugitive Methane Emissions)

Natural gas is composed primarily of methane, which is 28 times more potent than carbon dioxide.[12] Studies have increasingly revealed that natural gas leaks may be contributing a significant amount to GHG emissions. In 2015, a Harvard study found that 2.7% of all natural gas distributed in the Boston area is leaked and released into the atmosphere.[13] This Harvard study was referenced in The Town of Acton Methane Survey 2017 and was used here to estimate natural gas leaked as a result from natural gas consumption in the Town of Acton in 2017. Based on total natural gas used in Town of Acton, an estimated 211,750 therms of natural gas were leaked in 2017, corresponding to 9,652 $MTCO_2e$ of GHG emissions.

[12] According to IPCC Assessment Report 5, 2014.

[13] Summary of study available at https://www.seas.harvard.edu/news/2015/01/boston-s-natural-gas infrastructure-releases-high-levels-of-heat-trapping-methane

To arrive at this GHG emission value, the amount of natural gas in therms was converted to a volume of natural gas using the energy content of natural gas (1 MCF = 10.37 therms). The amount of methane contained in the natural gas was estimated at 90% of the total gas based on natural gas composition information, also referenced in the Town of Acton Methane Survey. Because fugitive natural gas leaks into the atmosphere and is not combusted, this volume of methane was converted to a mass using the density of methane at standard temperature and pressure, and lastly, the GWP of methane applied to arrive at the $MTCO_2e$ value.

Alternatively, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories provides emissions factors for fugitive natural gas (Chapter 4; Table 4.2.4 and 4.2.5). While the IPCC methods are created and reviewed by leading scientists worldwide, the assumptions associated with these factors are unclear, such as the percent of gas leaked. It is also unclear if this is to be associated with larger leaks, or simply fugitive emissions from standard gas distribution and consumption. The IPCC emissions factors results in 654 $MTCO_2e$ from fugitive emissions, or only approximately 7% of the value calculated using the method described above. This highlights that there is still much uncertainty surrounding gas leak emissions and standardized GHG protocol guidance does not yet exist.

Actual emissions in Acton may be higher than 2.7% of natural distributed. Natural gas pipes in Acton are under 120 times more pressure than natural gas pipes in Boston – the region most directly covered by the Harvard leak study. The Town of Acton Methane Survey 2017 provided data on the surface area of measured natural gas leaks and a 1-3 grading of their intensity based on the Department of Transportation's Pipelines and Hazardous Materials Safety Administration grading system. The study did not include measurements of the size of the pipe leak or of the amount of natural gas leaked over the course of the year. KLA determined that not enough data was present to complete an Acton-specific estimate of natural gas leakage and instead opted to use the more generalized 2.7% regional factor. Future studies of natural gas leaks in Acton may yield additional data to perform a more detailed, local estimate.

It should be noted that GWP calculations base calculations on the amount of energy emissions of GHGs will absorb over a specified time period, providing a common unit of measure. To be consistent with other studies, this report uses the 100-year time horizon for GWP. On occasion, some studies consider a 20-year time-horizon as an alternative to better reflect near term implications of GHG emissions. Such a consideration has implications for the relative GWPs of different gases. Using a 20-year GWP would create large GWPs for gases with lifetimes shorter than CO_2. Thus, the 20-year GWP of CH_4, which has a shorter lifetime than CO_2 would be much higher than the 100-year GWP and increase the relative contributions of CH_4-related emissions sources to the inventory.

Solar Capacity

Though not accounted for independently in the inventory, Table 14 provides solar energy capacity and generation data for PV installations in the Town. This information is sourced from NREL OpenPV, a comprehensive database of solar installations in the U.S. The values reported exclude the Acton Landfill Solar Project, which has a capacity of 1591 kW. The Town of Acton sells the RECs associated with

electricity production from the landfill project. Solar capacity (kW) is reported to OpenPV, while generation (kWh) is estimated using the provided capacity, multiplying by hours in a year and the average solar capacity factor in Massachusetts. In total, PV arrays in Acton have a capacity of 2,988 kW and an approximate annual generation of 3,533 MWh.

Table 14. Solar Energy Capacity and Generation

Source	Capacity (kW)	Annual Generation (MWh)
Commercial	1212.5	1433.90
Residential	1401.7	1657.65
Government	78.5	92.83
Non-Profit	5.1	6.03
Educational	290.0	342.95
Total	**2987.8**	**3533.37**

4.3. Transportation

The transportation sector produced a total of 123,866 $MTCO_2e$. The associated VMT and fuel consumption are captured in Table 15 and Table 16. As illustrated in Figure 7, on-road transportation is the predominant transportation-related emissions source for the Town.

Table 15. Community Transportation Energy Sources by Sector

Source	Vehicle Miles Traveled (VMT)	Emissions (MTCO2e)
Passenger	189,216,181	113,496
Commercial	11,967,360	7,116
Total	201,183,540	120,612

Table 16. Community Transportation Fuel Consumed

Fuel	Quantity Consumed (gal)	Emissions (MTCO2e)
On-Road Gasoline	8,999,874	79,338
On-Road Diesel	4,040,923	41,274
Rail Diesel	350,874	3,582

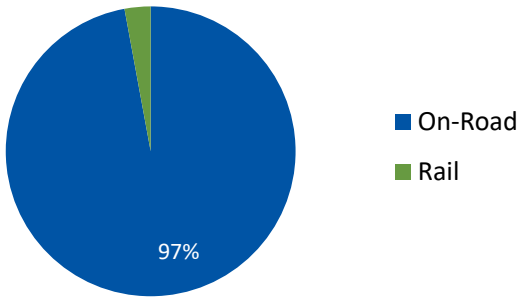

Figure 7. Summary of Community Transportation GHG Emissions

4.4. Waste

The waste sector produced a total of 7,982 $MTCO_2e$. MSW contributed 70.4%, while wastewater treatment contributed 29.6%

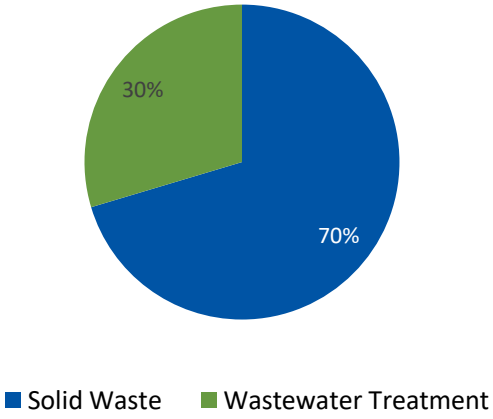

Figure 8. Summary of Community Waste GHG Emissions

Solid Waste Disposal

Though the residential sector produces a greater quantity of MSW than the commercial sector, approximately 39% of that waste collected is diverted as recycling. As a result, commercial waste is responsible for a greater proportion of waste-related emissions.

Table 17. Community Waste Collection and Processing Summary

Source	Transfer Station		Independent Hauler		Total (tons)	Emissions (MTCO2e)
	Waste	Recycling	Waste	Recycling		
Residential	951	1,212	2,666	1,085	5,914	2,593
Commercial	-	-	4,219	-	4,219	3,024
Total	951	1,212	6,885	1,085	10,133	5,617

Wastewater Treatment

Figure 9 illustrates the composition of wastewater-related emissions based on system and treatment type.

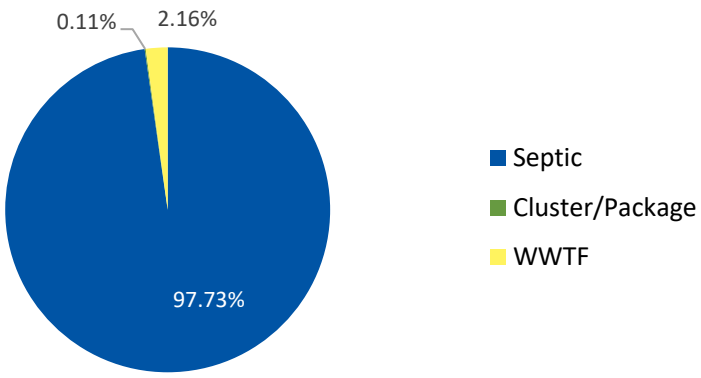

Figure 9. Wastewater GHG Emissions by Treatment System Type

Septic systems were the primary contributor of wastewater treatment-related emissions due to their production of methane, and their prevalence as a treatment method in the Town. While wastewater treatment facilities may also produce large quantities of methane, the type of treatment processes used in Acton (aerobic vs. anaerobic) do not. This is due to the presence of oxygen in the treatment process.

4.5. Carbon Sequestration from Conservation Land

Forested areas can retain significant amounts of carbon in the woody matter of trees and in soils. Calculating the amount of carbon stored in these areas is estimated using the data on tree diameter and age by tree or forest type. The Natural Resources Division of Acton provided KLA with information regarding diameter at breast height (DBH), tree age by conservation parcel, tree type within each parcel and total area for each parcel. This information is summarized in the appendix. Carbon storage factors for the Northeastern States of Connecticut, Massachusetts, New Hampshire and Rhode Island[14] by tree type and age were obtained from the USDA's and National Council for Air and Stream Improvements (NCASI) Carbon Online Estimator[15] (COLE). Carbon sequestration was then converted in metric tons carbon dioxide equivalent. Total above ground storage is estimated at 554,844 $MTCO_2e$ while below ground storage is estimated at 439,430 $MTCO_2e$.

Though typically not included in GHG inventories, carbon storage in forest land may provide the Town of Acton with a revenue stream or credits to reach GHG reduction targets through participation in an

[14] Although factors were available specifically for Massachusetts, this data set in COLE was not big enough to include all the tree types present in Acton. The larger 4-state area was included in the analysis to get regional factors for all tree types in Acton conservation lands.

[15] COLE tool available at: http://www.ncasi2.org/COLE/

established carbon credit platform such as City Forest Credits[16]. KLA recommends further investigation into certifying organizations to determine the viability and cost of these options.

5. Municipal Inventory Results

5.1 Summary

Acton's municipal operations released 12,722 $MTCO_2e$ in 2017. This is less than 6% of the total community emissions. The largest sector source of emissions is the municipal facilities and infrastructure, which includes emissions from schools, followed by emissions from the operation of Acton wastewater treatment plant and conveyance of wastewater. The Town off-road vehicle fleet was the third largest source of GHG emissions in 2017. See Table 18 and Figure 10 for more detail on emissions by sector.

Table 18. Acton 2017 Municipal GHG Emissions by Sector

Sector	Emissions (MTCO2e)	Percent of Municipal Inventory
Facilities and Infrastructure	3,995	32%
Wastewater Treatment Facilities	2,650	21%
Vehicle Fleet - Off Road	2,610	21%
Vehicle Fleet - On Road	1,641	13%
Employee Commute	829	6.6%
Water Treatment & Delivery	627	5.0%
Solid Waste	324	0.7%
Streetlights and Traffic Signals	47	0.4%
Grand Total	**12,722**	**100%**

[16] https://www.cityforestcredits.org/

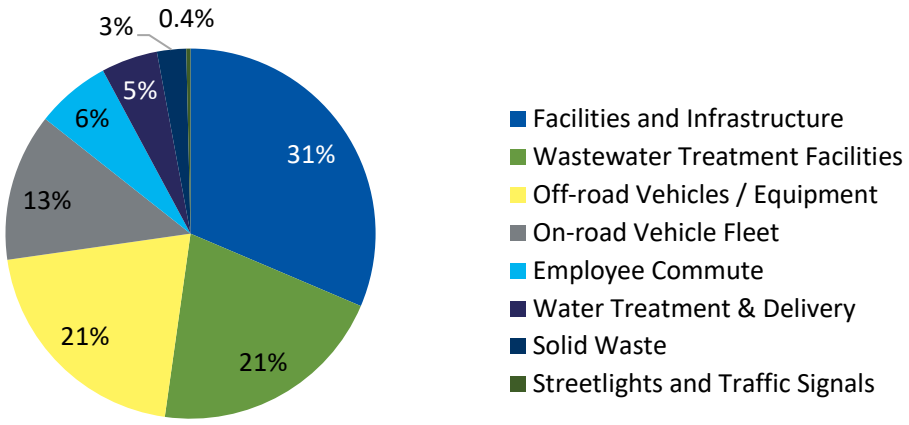

Figure 10. Acton 2017 Municipal GHG Inventory by Sector

5.2 Emissions by Source and Activity

The largest single source of municipal GHG emissions in 2017 was gasoline consumption in the municipal fleet as well as personal employee vehicles used to commute to and from municipal workplaces. Electricity usage was the second largest source, followed by wastewater-associated emissions, as shown in Figure 11.

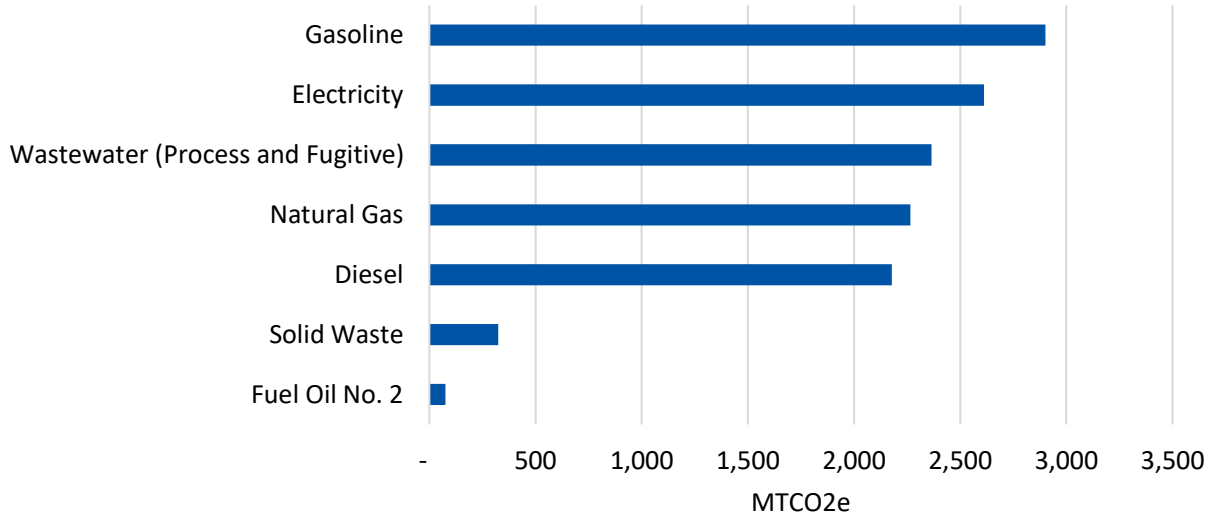

Figure 11. Acton 2017 Municipal GHG Emissions by Source

Table 19 identifies the amount of GHG emissions (in $MTCO_2e$) released by each source and sector. Just over half of the GHG emissions from Acton's facilities and infrastructure sector came from natural gas use. Process and fugitive emissions (the methane and nitrous oxide released through the treatment

process) were the dominant source in wastewater treatment operations, accounting for 89% of emissions from this sector. Gasoline vehicles accounted for 66% of emissions from the Employee Commute sector. Of government owned on-road vehicles, 62% of emissions came from diesel burning vehicles. Gasoline vehicles accounted for 66% of Town off-road vehicle emissions while electricity made up the majority of emissions from water treatment.

Table 19. Acton 2017 Municipal GHG Emissions by Sector and Source

Sector	Source	Emissions ($MTCO_2e$)	Percent of Sector
Facilities and Infrastructure	Electricity	1,770	44%
	Fuel Oil No.2	53	1%
	Natural Gas	2,171	54%
Wastewater Treatment Facilities	Electricity	263	10%
	Fuel Oil No.2	22	1%
	Wastewater (Process and Fugitive)	2,365	89%
Employee Commute	Diesel	284	34%
	Gasoline	545	66%
Vehicle Fleet - On Road	Diesel	1,011	62%
	Gasoline	630	38%
Vehicle Fleet - Off Road	Diesel	883	34%
	Gasoline	1,727	66%
Solid Waste	Landfill Waste	324	100%
Water Treatment & Delivery	Electricity	534	85%
	Natural Gas	93	15%
Streetlights and Traffic Signals	Electricity	47	100%
Grand Total		**12,722**	

Overall, the Public Works Department, which includes multiple sub-departments was responsible for the majority of emissions from the Town at 7,050 $MTCO_2e$. This is very common given the number and type of assets the Public Works Department is responsible for. Within the Public Works Department, the Highway Department accounted for 3,610 $MTCO_2e$, wastewater treatment accounted for 2,650 $MTCO_2e$ and the Municipal Properties Department accounted for 790 $MTCO_2e$.

Electricity and natural gas use by the ABRSD, as well as the diesel fuel used in Acton school buses, amounted to the second largest contributor at 3,980 $MTCO_2e$. Employee commute contributed 829 $MTCO_2e$ while water treatment contributed 627 $MTCO_2e$. Employee commute data considers commute associated with Town of Acton employees, and not the approximately 1,100 employees associated with ABRSD. Should those commuters be considered, employee commute values would increase by approximately 3,800 $MTCO_2e$, assuming similar commute distances and fuel consumption for school employees as town employees. This would make employee commuting the largest GHG contributor for the town. See Table 20 for more detail on emissions by department for the Town of Acton.

Table 20. Acton 2017 Municipal GHG Emissions by Department

Department	Subdepartment	Emissions ($MTCO_2e$)
Public Works	Highway	3,847
	Wastewater Treatment	2,650
	Municipal Properties	790
Schools	Schools	3,980
Employee Commute	Employee Commute	829
Acton Water District	Acton Water District	627
Grand Total		**12,722**

Electricity, natural gas and fuel oil consumption in the Facilities and Infrastructure sector accounted for approximately 32% of the Town's total GHG emissions. Figure 12 provides emissions by fuel from each subsector within the Facilities and Infrastructure sector. Although Schools can be considered its own sector, emissions from Schools are included here for comparison purposes. This chart does not include energy use from water treatment, wastewater treatment or streetlights and traffic signals. Relative to the Facilities and Infrastructure sector, Schools consume the vast majority of electricity and natural gas and emit 81% of total emissions. Libraries and Fire/Police emit the second and third most emissions, 7% and 5%, respectively. Public Works (not including on-road, off-road vehicles or wastewater treatment) accounted for approximately 3% of emissions and Administration accounted for 2%. Recreation and Cemetery each accounted for less than 1% of total emissions.

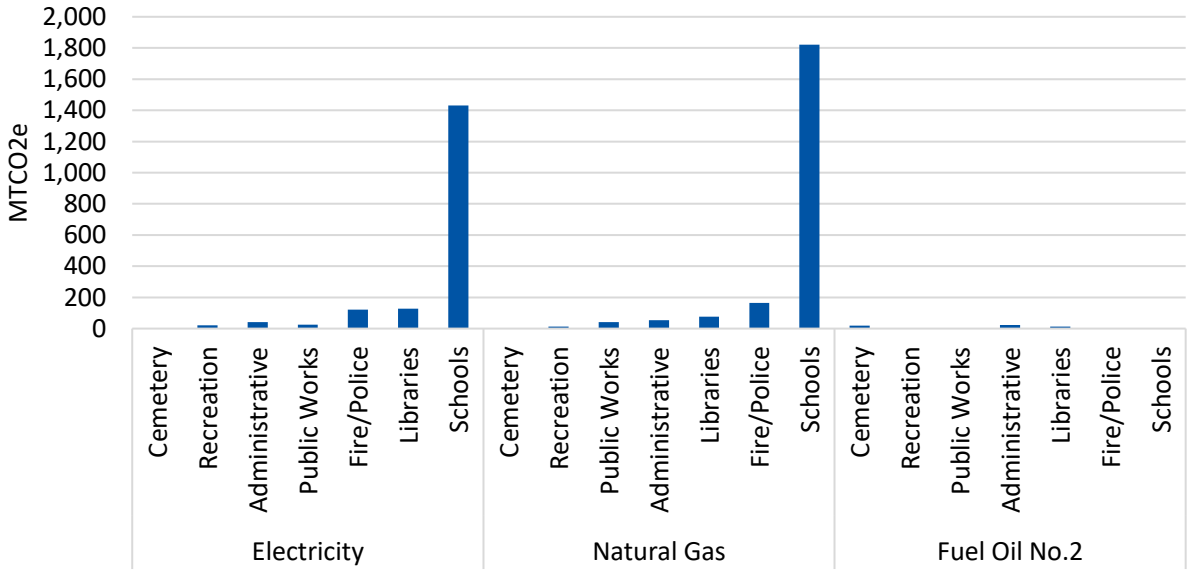

Figure 12. Acton 2017 Municipal Facilities and Infrastructure GHG Emissions from Electricity and Natural Gas by Department

6. Recommendations

To reduce greenhouse gas emissions and the carbon footprint of the Town of Acton, this report recommends assessing options in the highest community emission sectors as indicated by the community GHG inventory. Passenger vehicle travel and residential stationary energy use represent key target areas. Prioritized options include:

- Expansion of public transit or ride-sharing/carpooling opportunities to address transportation sector emissions,
- Encouragement of conversion of private vehicles to EV through expansion of EV charging stations throughout the Town,
- Further integration of renewable energy through program such as Acton Power Choice,
- Strategic electrification of stationary energy via the conversion of fuel oil heating systems to electric heating systems in residential and commercial buildings, and
- Pursuit of energy efficiency programs available via Mass Save to reduce energy consumption in both the residential and C&I sectors.

Other opportunities to reduce emissions include:

- Further assessment and repair of natural gas leaks,
- Potential expansion of centralized wastewater treatment in capital planning to encompass some households currently on septic systems,
- Increased commercial recycling to divert waste from landfill, and
- Electrification of the municipal vehicle fleet through the procurement of electric vehicles.

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Appendix A. Carbon Sequestration Data

Conservation Parcel	Acreage	Forest Description	Average DBH	Percent of Local Area	Hectares	Soil (tonnes carbon/hectare)*	Non-Soil (tonnes carbon/hectare)*	Soil Tonnes Carbon	Non Soil Tonnes Carbon
Grassy Pond Conservation Area	**96**	60% Deciduous Forest: 40 to 60 yrs old	24 - 30"	60%	57.6	53.08	88.53	3,057	5,099
		25% Red Maple Swamp	12 -24"	25%	24	111.67	76.51	2,680	1,836
		10% White Pine: 70 - 90 yrs old	30"	10%	9.6	78.64	114.94	755	1,103
		5% Open Field	Tall grass meadow	5%	4.8			0	0
Nagog Hill Conservation Area	**177**	45% Deciduous Forest: 40 - 60 yrs old	24 - 30"	45%	79.65	53.08	88.53	4,228	7,051
		40% White Pine: 40 - 60 yrs old	24 - 36"	40%	70.8	78.64	107.5	5,568	7,611
		10% Red Maple Swamp	12 -24"	10%	17.7	111.67	76.51	1,977	1,354
		5% Open Field	Tall grass meadow	5%	8.85			0	0
Acton Arboretum	**65**	40% White Pine: 40 - 60 yrs old	30 - 36"	40%	26	78.64	107.5	2,045	2,795
		25% Red Maple Swamp	12 - 24"	25%	16.25	111.67	76.51	1,815	1,243
		30 % Deciduous Forest: 40 - 70 yrs old	18 - 24"	30%	19.5	53.08	97.855	1,035	1,908
		5% open lawn with trees introduced (formal arboretum)		5%	3.25			0	0
Great Hill Conservation Area	**192**	55% Deciduous Forest: 60 - 90 yrs old	24 - 30"	55%	105.6	53.08	129.615	5,605	13,687
		20% Red Maple Swamp	18 - 24	20%	38.4	111.67	99.39	4,288	3,817
		20% White Pine: 60 - 90 yrs old	30 -40"	20%	38.4	78.64	140.475	3,020	5,394

		5% Open Playfield	Maintained lawn	5%	9.6			0	0
Guggins Brook Conservation Area	**61**	70% Red Maple Swamp	18 -24"	70%	42.7	111.67	99.39	4,768	4,244
		30% White Pine/Hemlock Forest: 40 - 80 yrs old	30 - 40"	30%	18.3	78.13	106.65	1,430	1,952
Bulette Town Forest	**47**	50% Red Maple Swamp	18 - 24"	50%	23.5	111.67	99.39	2,624	2,336
		30% Deciduous Forest 50 - 80 yrs old	24 - 36"	30%	14.1	53.08	123.09	748	1,736
		20% White Pine: 40 - 80 yrs old	24 - 40"	20%	9.4	78.64	123.77	739	1,163
Anderson Conservation Land	**20**	60% White Pine: 40 - 70 yrs old	24 - 36"	60%	12	78.64	115.635	944	1,388
		30% Red Maple Swamp	18- 24"	30%	6	111.67	99.39	670	596
		10% Deciduous Forest: 40 - 70 yrs old	20 - 30"	10%	2	53.08	97.855	106	196
Camp Acton	**56**	50% Deciduous Forest: 60 - 90 yrs old	24 - 36"	50%	28	53.08	123.09	1,486	3,447
		30% White Pine: 60 - 90 yrs old	30 - 36"	30%	16.8	78.64	140.475	1,321	2,360
		10% Red Maple Swamp	18 - 24"	10%	5.6	111.67	99.39	625	557
Heath Hen Conservation Area	**113**	40% Open Marsh/Floodplain		40%	45.2			0	
		30% Red Maple Swamp	18 - 24"	30%	33.9	111.67	99.39	3,786	3,369
		20% Dedicuous Forest: 50 - 80 yrs old	18 - 24"	20%	22.6	53.08	123.09	1,200	2,782
		5% White Pine: 50 - 80 yrs old	24 - 36"	5%	5.65	78.64	129.89	444	734
		2% Open Field	Tall grass meadow	2%	2.26			0	0
Jenks Conservation Land	**28**	50% Open Orchard: **mowed once, annually**		50%	14			0	

Early succession apple orchard and wetland habitat		20% Open Marsh/Floodplain		20%	5.6			0	
		10% Red Maple Swamp	18 - 24"	10%	2.8	111.67	62.56	313	175
		10% White Pine	12 - 18"	10%	2.8	78.64	86.86	220	243
		10% Deciduous Forest: 40 - 50 yrs old	18 - 24"	10%	2.8	53.08	78.235	149	219
Nashoba Brook Conseration Area	**123**	50% Deciduous Forest: 60 - 80 yrs old	18 - 30"	50%	61.5	53.08	123.09	3,264	7,570
		30% White Pine: 60 - 80 yrs old	24 - 36"	30%	36.9	78.64	136.01	2,902	5,019
		10% Red Maple Swamp	12 - 18"	10%	12.3	111.67	33.14	1,374	408
		10% Open Marsh/Floodplain: **Nashoba Brook**		10%	12.3			0	
Pacy Conservation Area	**38**	50% White Pine: 60 - 80 yrs old	24 - 36"	50%	19	78.64	136.01	1,494	2,584
		40% Red Maple Swamp	18 - 24"	40%	15.2	111.67	62.56	1,697	951
		10% Deciduous Forest: 60 - 80 yrs old	18 - 30"	10%	3.8	53.08	123.09	202	468
Pratt's Brook Conservation Area	**59**	40% Deciduous Forest in Pine Barren: 40 yrs old	12 - 24"	40%	23.6	53.08	67.94	1,253	1,603
		30% Red Maple Swamp	18 - 24"	30%	17.7	111.67	62.56	1,977	1,107
		30% White Pine: 60 - 90 yrs old	24 - 36"	30%	17.7	78.64	140.475	1,392	2,486
Robbins Mill	**95**	55% Deciduous Forest: 40 - 50 yrs old		55%	52.25	53.08	78.235	2,773	
		40% Red Maple Swamp (Nashoba Brook)		40%	38	111.67	76.51	4,243	2,907
		5% White Pine: 50 - 70 yrs old		5%	4.75	78.64	123.77	374	
Spring Hill Conservation Area	**213**	60% Deciduous Forest: impacted by Gipsy Moths	18 - 24"	60%	127.8	53.08	123.09	6,784	15,731
		30% Red Maple Swamp	18 - 24"	30%	63.9	111.67	62.56	7,136	3,998

		10% White Pine: 60 - 90 yrs old	24 - 36"	10%	21.3	78.64	140.475	1,675	2,992
Stoneymeade	**45**	50% Red Maple Swamp	18 - 24"	50%	22.5	111.67	62.56	2,513	1,408
		30% Deciduous Forest: 30 - 50 yrs old	12 - 24"	30%	13.5	53.08	67.94	717	917
		10% White Pine: 60 - 90 yrs old	24 - 36"	10%	4.5	78.64	140.475	354	632
		10% Open Field	Mowed once annually	10%	4.5	0	0	0	0
Wetherbee	**73**	50% Farm Field: **managed by MCI Concord**		50%	36.5			0	0
		25% Deciduous Forest: 40 - 60 yrs old	12 - 24"	25%	18.25	53.08	88.53	969	1,616
		20% White Pine: 40 - 60 yrs old	18 - 30"	20%	14.6	78.64	107.5	1,148	1,570
		5% Red Maple Swamp/Wetland	12 - 20"	5%	3.65	111.67	47.66	408	174
Wills Hole	**40**	90% Wetland Bog/Shrub/Redmaple Swamp		90%	36	111.67	62.56	4,020	
		10% Deciduous Forest: 40 - 60 yrs old	18 - 24"	10%	4	53.08	88.53	212	354
Town Forest	**50**	80% Deciduous Forest: harvested as recently as the 1970's.	12 - 24"	80%	40	53.08	67.94	2,123	2,718
		10% White Pine: 60 - 90 yrs old	24 - 36"	10%	5	78.64	140.475	393	702
		10% Red Maple Swamp	18 - 24"	10%	5	111.67	62.56	558	313
Total large acreage parcels:	**1591**								
The remaining 184.47 acres not accounted for in this report are comprised of many smaller pacels of Conservation Land throughout Acton. Most of these are wetlands, primarily Red Maple Swamp, 18 - 24" DBH, with an average age of 40 to 60 years.				**50%**	92.235	111.67	62.56	10,300	

Total Soil	Total Non-Soil	
119,899	151,321	Tonnes Carbon
3.666666667	3.666666667	Conversion from C to CO2 is 44/12
439,630	554,844	MTCO2e