2019 Greenhouse Gas Emissions Inventory
Detailed Report

Local Government Operations ∘ Community-Wide Accounting

Concord, New Hampshire

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Picture of the Concord NH State House from visitconcord-nh.com.

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1. Executive Summary

According to the Intergovernmental Panel on Climate Change (IPCC), global society will have to reduce carbon dioxide (CO_2) emissions by about 45% from 2010 levels by 2030, achieving net-zero CO_2 emissions by 2050[1]. Globally, cities occupy about two percent of the planet's land mass but account for up to seventy percent of greenhouse gas (GHG) emissions[2].

To combat GHG emissions, Concord, New Hampshire, adopted a 100% renewable energy goal by unanimous vote of the City Council in 2018[3]. The city also committed to the NH Climate Action Plan[4] and the Climate Mayors Agreement. This GHG inventory was created to help Concord prioritize strategies that are cost-effective and significantly reduce emissions, to reach the city's commitments and global scientific GHG targets, to engage stakeholders in reducing emissions, to prioritize responsibilities for a sustainability staff member, and to help the city develop a climate action plan. This inventory also defined a replicable baseline for future inventories.

This report looked at the city of Concord in 2019 through two separate lenses: (1) local government operations (LGOs), and (2) community-wide accounting. Data for several emission and removal sources were collected and prepared to be used in GHG emission and removal calculations.

Local government operations. In 2019, we estimated that the City's LGOs released 12,049 metric tons of carbon dioxide equivalent (MT CO_2e) in GHG emissions. Stationary fuel (primarily for building heat) comprised over a quarter of the emissions (27%; 3,265 out of 12,049 MT CO_2e). Wastewater treatment (26%) and electricity use (21%) were the second and third largest emission sources.

When exploring emissions reduction strategies, the City should focus on reducing energy use in facilities, starting with the Hall Street and Penacook Wastewater Treatment Plants (WWTPs), the Water Treatment Plant (WTP), the Douglas N Everett Ice Arena, and the Combined Operations Maintenance Facility (COMF). Reducing electricity use in all City facilities will also reduce the amount of renewable energy certificates the City buys. Furthermore, the City should focus on reducing emissions from vehicle fleets and employees commuting to work.

Community-wide accounting. In 2019, we estimated that the Concord community released 495,905 MT CO_2e in gross GHG emissions. Including the removal of carbon by forests, the net GHG emissions from the community was 483,443 MT CO_2e. Stationary fuel (primarily for building heat) comprised a little over one-third of the gross emissions released by the community (35%; 175,551 out of 495,905 MT CO_2e). In addition, transportation (28%), electricity use (18%), and industrial processes (15%) contributed the largest emissions in 2019 (**Figure 1.1A**). The commercial and institutional sector accounted for half of the gross GHG emissions in Concord (50%; 245,802 out of 495,905 MT CO_2e), whereas the residential sector accounted for 48% of the gross emissions (239,353 MT CO_2e) [**Figure 1.1B**].

While climate action planning, the City should focus on natural gas and other heating fuel combustion from stationary fuels, passenger cars and light trucks from transportation, and electricity consumption. It is not clear what commercial businesses emit the most GHGs from this study; however, identifying and working with the largest entities in Concord may significantly reduce community-wide emissions.

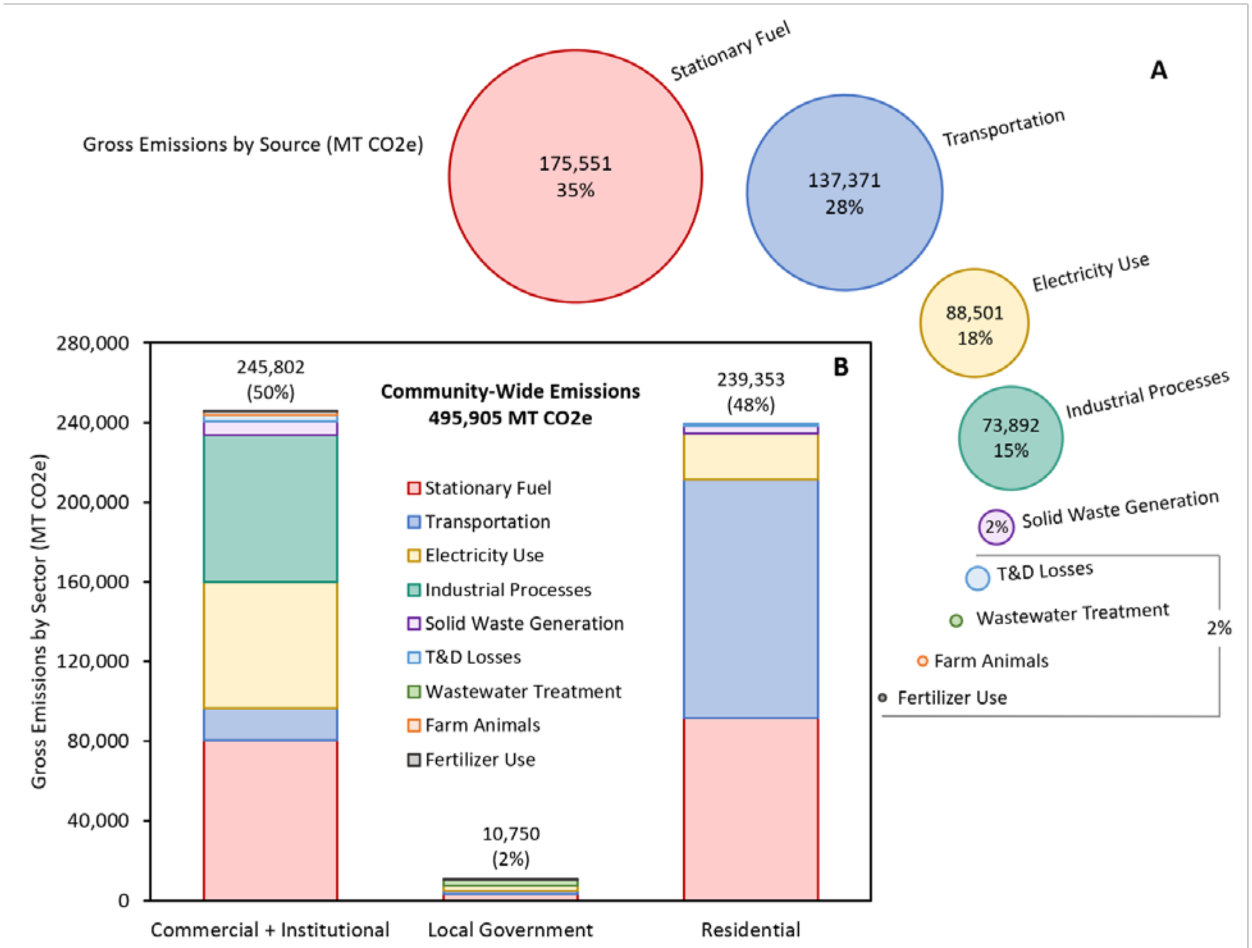

Figure 1.1: Estimated gross GHG emissions (MT CO_2e) emitted by each community source (**A**) and sector (**B**) in 2019. **Figure 1.1A** shows the percent of gross emissions for the five largest sources and sums the emissions of the four smallest sources. **Figure 1.1B** shows the total amount and percentage of gross emissions for each sector (*i.e.*, commercial + institutional, local government, and residential). The legend is ordered from largest to smallest source. T&D is transmission and distribution. Commercial + institutional includes commercial businesses, industrial facilities, public schools, public housing, and state government. A similar figure is in the **Community-Wide Inventory Overview** with a pie chart.

2. Introduction

The Fight Against Climate Change

The consequences of us. Climate change is a global problem. In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released the Special Report on Global Warming of 1.5°C, warning the world that we must limit temperature rise to below 1.5°C to avoid the devastating outcomes of climate change[1]. Global society will have to reduce carbon dioxide (CO_2) emissions by about 45% from 2010 levels by 2030, achieving net-zero CO_2 emissions around 2050[1]. In the past few decades, rising temperatures have worsened extreme weather events (*i.e.*, floods, droughts, and heat waves)[5–7], wildfires have decreased forest resilience[8,9], coral reefs have been bleached of their colors[10–12], climate changes have influenced the spread of infectious diseases[13], and food supply security is threatened[14]. The detrimental effects of climate change are caused by humans rapidly adding to the natural greenhouse effect—the process in which the Earth's atmosphere traps some of the Sun's energy—with gases released from industry and agriculture, trapping more energy and increasing the global temperature[15]. Just last year (2019) was the second warmest year on Earth since 1850 (**Figure 2.1**)[16].

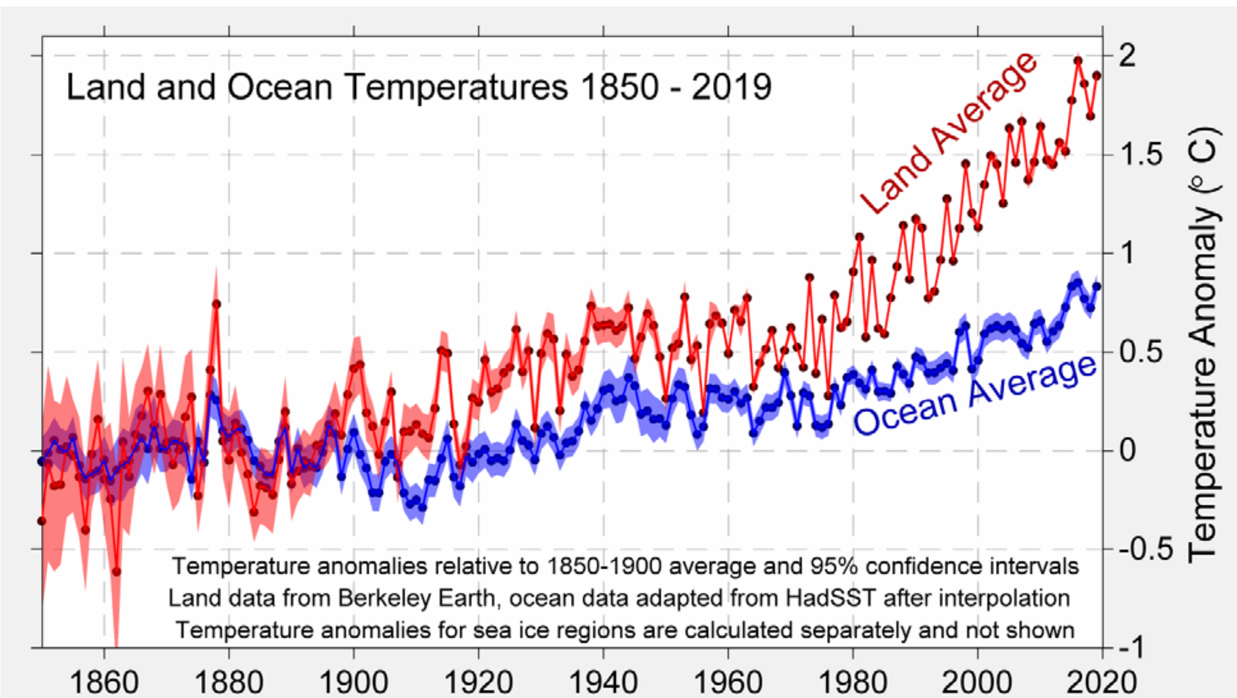

Figure 2.1[16]: Land and ocean temperature changes relative to the average from 1850 to 1900. The tendency for land averages to increase more quickly than ocean averages is clearly visible.

The need to localize the fight. Cities are vulnerable to global environmental change, where over 90% of all urban areas are coastal and at risk for flooding from rising sea levels and power storms[17]. New Hampshire, specifically, has experienced the negative impacts of climate change, such as rising temperatures, shorter winters, more extreme weather events resulting in water shortages and floods, respiratory illness from air pollution and heat, spread of infectious diseases like Lyme disease, and threats to the wellbeing of its native habitats and wildlife[3]. Globally, cities occupy about two percent of the planet's land mass but consume two-thirds of the world's energy and account for up to seventy percent of greenhouse gas (GHG) emissions[2]. The decisions communities make at the local scale can result in the global emissions reductions needed to reach the IPCC's net-zero emissions recommendation. However, a *city's ability to take effective action on mitigating climate change and monitoring progress depends on having access to good quality data on GHG emissions*[18].

Striving Towards 100% Renewable Energy

State- and city-level action. In March 2009, the New Hampshire Department of Environmental Services (NHDES) completed the New Hampshire Climate Action Plan, which recommends that New Hampshire achieve long-term GHG emissions reductions of 80% below 1990 levels by 2050[4]. The plan lists over sixty actions to reduce GHG emissions from buildings, electric generation, and transportation as well as protect NH natural resources, increase education and outreach, and adapt to the impacts of climate change[4].

The City of Concord (referred to as "City") government has taken several steps to reduce its climate footprint and energy usage, such as:

- Embracing the NH Climate Action Plan to reduce GHG emissions 80% by 2050;
- Investing in energy efficiency projects and purchasing green energy for City buildings; and
- Signing the Climate Mayors Agreement to uphold the Paris Climate Accord and develop a climate action plan[3].

In July 2018, the City of Concord adopted a 100% renewable energy goal by unanimous vote of the City Council[3]. The City committed to the following community-wide goals:

1. 100% of electricity consumed in Concord will come from renewable energy sources by 2030;
2. 100% of thermal energy (heating and cooling) consumed in Concord will come from renewable energy sources by 2050; and
3. 100% of transportation in Concord will be clean transportation by 2050[3].

One year later, the City of Concord's Energy and Environment Advisory (EEAC)—a local government committee formed in 2008 that recommends best sustainability practices for the community—drafted the 100% Renewable Energy Goal Strategic Plan to achieve these goals.

The strategic plan identified *energy and emissions tracking and interim targets as an important component of successful implementation*[3]. Previously, the EEAC conducted a preliminary community-wide carbon footprint analysis based on 2018 electricity usage, 2019 thermal consumption of natural gas, and 2018 vehicle transportation. From this initial analysis, they found that:

- The commercial sector emitted the most GHGs when compared with the residential and municipal government sectors;
- Emissions from commercial businesses and industries are high and unspecified;
- Transportation was the largest source of emissions, followed by natural gas consumption; and electricity
- The renewable energy certificates (RECs) purchased by the local government offset 100% of the city government's electricity-related GHG emissions.

The next step the EEAC identified was to *conduct a comprehensive GHG emissions inventory* to account for other GHG emitting sources (*i.e.*, agriculture, household heating fuel, solid waste generation, urban forestry, and wastewater treatment) using a standardized and replicable methodology. A GHG inventory allows cities to determine where to best direct mitigation efforts, create strategies to reduce GHG emissions, and track their progress[18].

The City of Concord

Located among rolling forested hills and agricultural lands in the heart of the Merrimack Valley, Concord is the capital city of New Hampshire and home to about 43,000 people (**Figure 2.2**). The city holds a seat of Merrimack County. In the beginning, Concord was initially settled in the village of Penacook—a site granted by the Massachusetts Bay colony in 1725 as Penacook Plantation[19]. In 1808, New Hampshire's legislature settled in the city after moving around several places[19]. Printing, an important industry in the city's development, was overshadowed by carriage making and granite quarrying[19]. By the end of the 19th century, railroads and repair shops were the prominent industry in Concord[19]. Today, Concord's economy is well diversified and includes agriculture, distribution, insurance, manufacturing, and medicine. Concord also offers a vibrant New England downtown, commerce center, and performing arts scene.

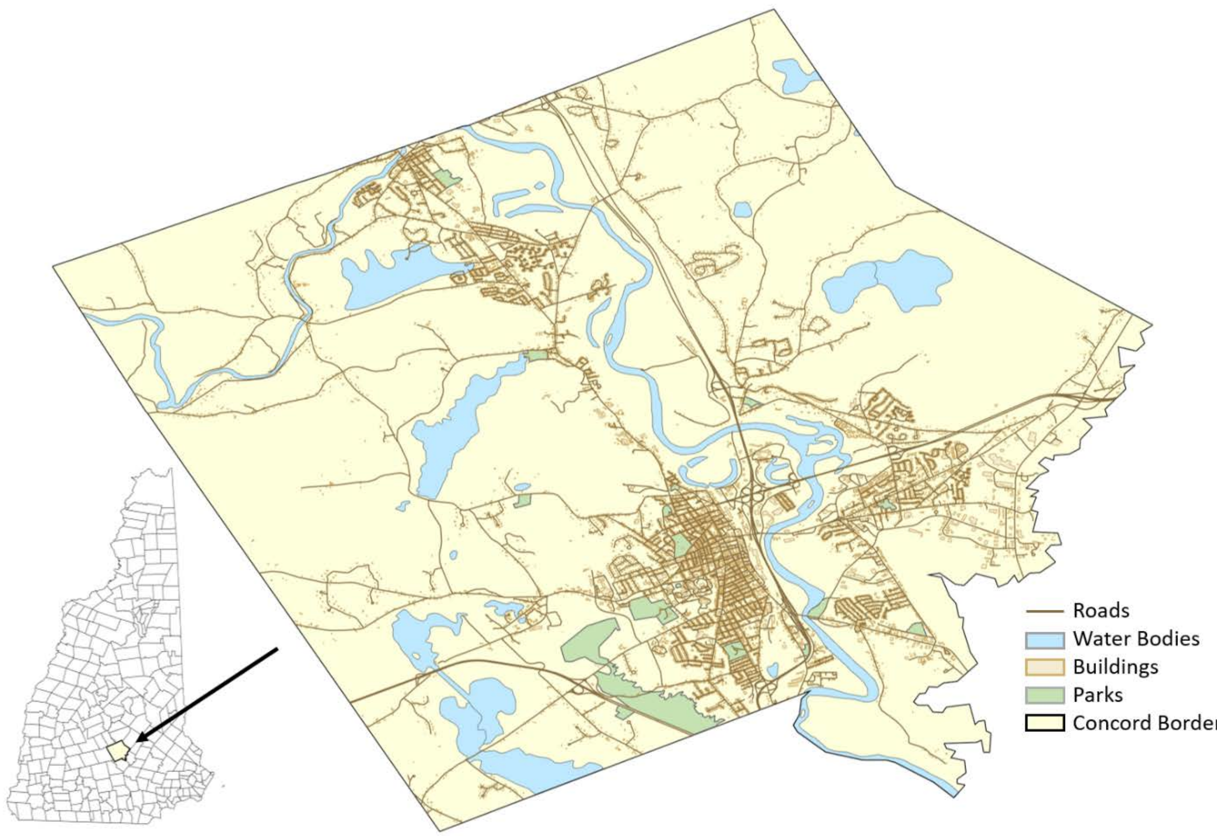

Figure 2.2: Map of Concord, New Hampshire. Roads were clipped from the 2020 NH Public Roads shapefile from NH GRANIT[20]. Water bodies were clipped from the 2010 (updated 2019) USA Detailed Water Bodies layer package from ESRI[21]. Buildings were clipped from the 2018 (release 1.1) NH Building Footprint GeoJSON from Microsoft[22]. Parks were clipped from the 2010 (updated 2019) USA Parks layer package from ESRI[23]. The Concord Border was clipped from the 2018 NH counties shapefile from the US Census.

The city spans 64 square miles (**Table 2.1**) with quite a few natural areas to explore: more than 80 miles of trails, 21 parks, and 7 community pools[24]. According to the 2018 American Community Survey (ACS) Five-Year Estimates, there were 17,242 occupied housing units in Concord. Less than half of these housing units were apartments (44%; 7,601 out of 17,242 units). The median household income was $62,967.

Table 2.1: Summary of the Concord community demographics

Population[a]	43,040 ± 59
Land Area (square miles)[d]	64.25
Population Density (people/square mile)	670
Housing	
All Housing Units[a]	18,378 ± 413
Occupied Housing Units[a]	17,242 ± 407
Single-Family Units[a,b,c]	8,696 ± 523
Apartments (2-4 units)[a,c]	2,660 ± 377
Apartments (≥5 units)[a,c]	4,941 ± 460
Mobile Homes or Other Housing[a,c]	945 ± 136
Economy	
Median Household Income[d]	$62,967
Tax Rate[e]	Concord: $28.24 Penacook: $32.26

[a]Data sourced from the 2018 American Community Survey (ACS) 5-Year Estimates Data Profiles. The 5-year estimates were chosen because they have a larger sample size, more reliable data, data available for all areas of the United States. ACS data tables used include DP04, S1101, and S2504. [b]Detached or attached single-family housing unit. [c]For occupied housing units. [d]Data sourced from US Census Bureau QuickFacts. [e]Data sourced from the Greater Concord Chamber of Commerce's "Guidebook to Greater Concord 2019-2020"[24].

Heating and Cooling

July 2019 was the turning point for space heating to space cooling in New Hampshire (**Figure 2.3**). Heating and cooling degree days were used to analyze this change. Degree days are measures of the cold or warm temperature in a location. A degree day compares the mean (the average of the high and the low) outdoor temperature recorded for a location to a standard temperature, usually 65^{o} Fahrenheit (F) in the US[25]. The more extreme the outside temperature, the higher the number of degree days[25]. A high number of degree days generally results in higher levels of energy use for space heating or cooling[25].

Heating fuel data was not normalized by heating and cooling degree days in 2019. The Local Government Operations Protocol (LGOP) requires degree day normalization when proxy years are used to estimate data[26]. When comparing data from different years, normalizing by total degree days for each year is good practice to analyze trends with limited noise. The total number of degree days in New Hampshire for the year 2019 was 8,038[27]. Total degree days (TDD) data were acquired from the National Climatic Data Center[27].

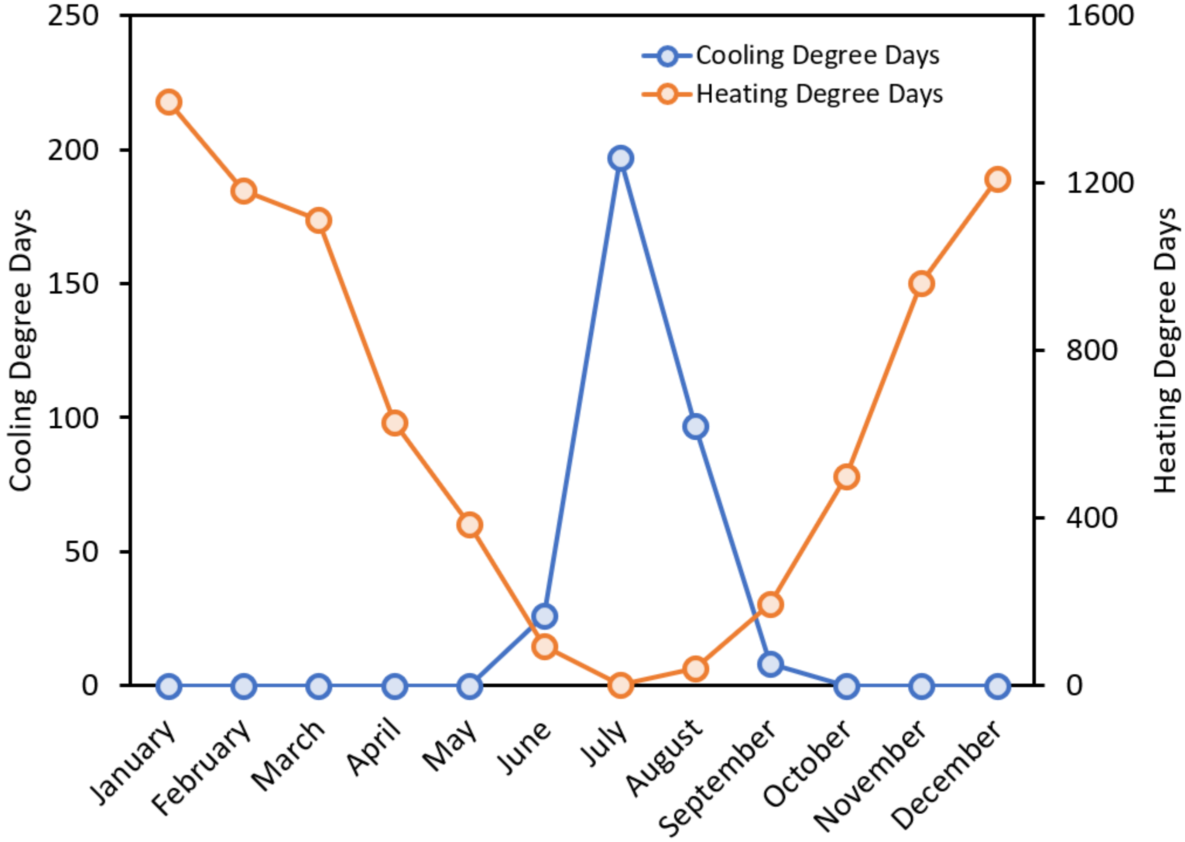

Figure 2.3: Heating and cooling degree days for each month in 2019 in Concord, NH. Data was retrieved from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center[27] .

3. Materials & Methods

Determining What to Measure

Purpose of this project. An important step for any community fighting climate change is to assess the amount of carbon emissions the community is responsible for releasing into the atmosphere. A greenhouse gas (GHG) emissions inventory estimates the quantity of GHG emissions and removals associated with community sources and activities taking place during a chosen analysis year[28]. Quantifying these emissions will help the City recommend strategies that are cost-effective, align with the city's clean energy and emissions commitments and global scientific GHG targets, progress towards the 100% renewable goal, engage stakeholders in reducing emissions, prioritize responsibilities for a sustainability staff member, and help develop a climate action plan.

Framing the story. The goal of this report is to present a full picture of the city of Concord's GHG emissions and removals for the year 2019. In the absence of 2019 data, any year from 2015 to 2019 was used to set a baseline. However, before undertaking an inventory, a community must make important decisions about what to measure, what the boundary area of the inventory will be, and what data sources to use to create the most accurate baseline of current local emissions to measure future progress against. This inventory looked at the Concord community through two separate lenses: (1) local government operations and (2) community-wide accounting (**Figure 3.1**).

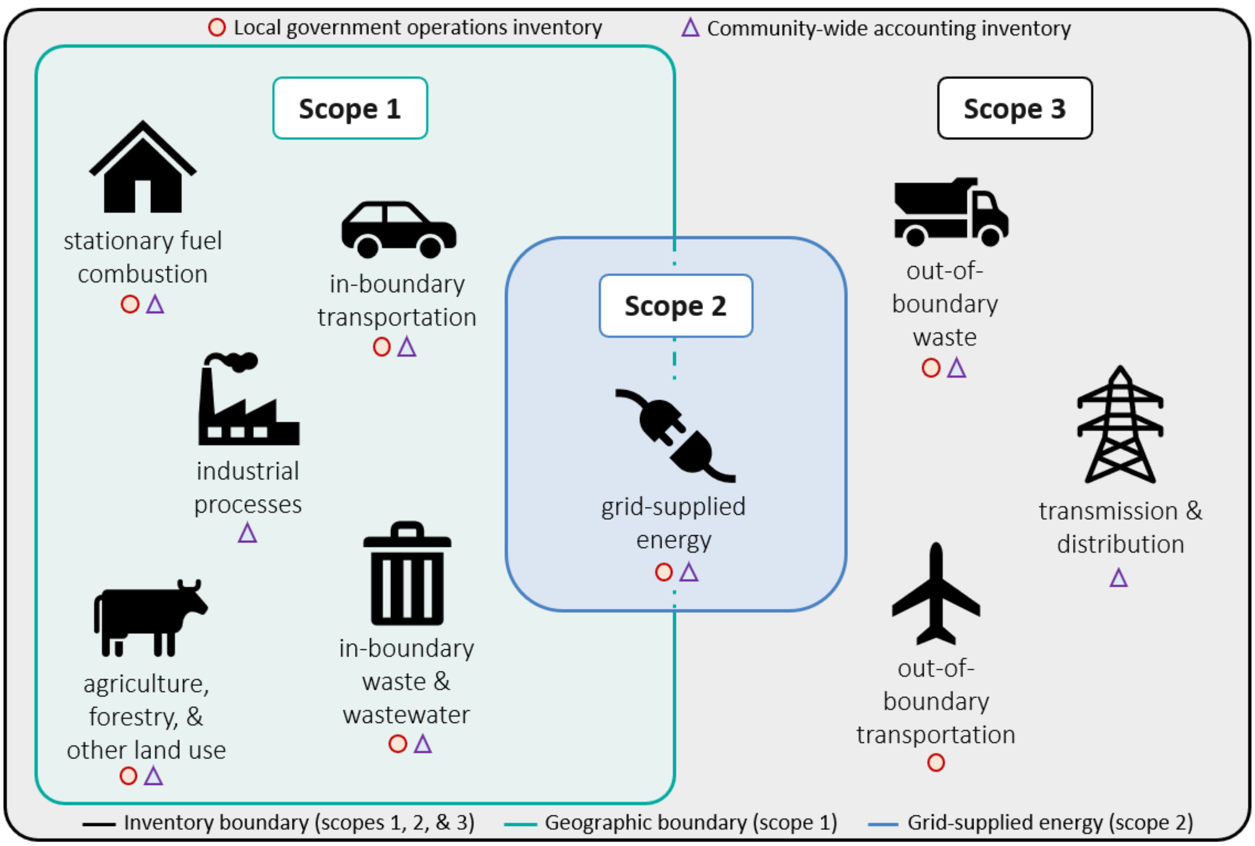

Figure 3.1: The scopes, sources, and boundaries of GHG emissions explored in each inventory. The sources included in each inventory are marked by the red circle (Local Government Operations Inventory) and the purple triangle (Community-Wide Inventory). This figure was adapted from the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories[18].

In greenhouse gas emissions inventorying, three scopes categorize different emission and removal sources. Scope 1 sources are GHG emissions or removals from sources located within the community boundary. Scope 2 sources are GHG emissions that occur because of the use of grid-supplied electricity, heat, steam, and/or cooling within the community boundary. Lastly, Scope 3 sources are all other GHG emissions and removals that occur outside the community boundary because of the activities taking place within the community boundary.

Local government operations. This inventory used the approaches and methods provided by the Local Government Operations Protocol (LGOP) version 1.1, which was released by The Climate Registry[26]. This inventory focused on emissions the City of Concord government has operational control over. The City government has operational control if it has the full authority to introduce and implement its operating policies at the facility[26].

Key Question

Since the EEAC conducted an initial carbon footprint, we were interested in defining one question about local government operations further:

1). What are the largest energy consumers in local government operations, and how much GHG emissions are emitted?

Community-wide accounting. This inventory used the approaches and methods provided by the United States Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (USCP) version 1.2, which was released by the ICLEI – Local Governments for Sustainability[28]. As required by the USCP, this inventory includes the five basic emissions generating activities:

1. Use of electricity by the community,
2. Use of fuel in residential and commercial stationary combustion equipment,
3. On-road passenger and freight motor vehicle travel,
4. Use of energy in potable water and wastewater treatment distribution, and
5. Generation of solid waste by the community[28].

This inventory focused on community emission and removal sources the City government has an opportunity to address through policy, projects, and stakeholder outreach. Interestingly, this means this inventory does not completely fit one of the USCP reporting frameworks (*i.e.*, significant local government influence, community-wide activities, and household consumption). This provided the City with the opportunity to tell a unique story on emission and removal sources of community interest. In Phase I of its execution, this inventory will also act as a working framework for a more comprehensive community inventory in the future.

Key Questions

The City was interested in identifying sources that will lead to the greatest and most immediate reductions. We brainstormed a list of questions regarding community-wide sources:

1). What are the biggest commercial and industrial sources of emissions?

2). In addition to residential vehicles, what other vehicle fleets contribute to GHG emissions?

3). In addition to natural gas, what other stationary fuels are combusted in Concord?

4). How much carbon dioxide does carbon sequestration remove from the Concord community?

Greenhouse Gas Accounting Tools

Three Microsoft Excel-based tools were used in this report to calculate GHG emissions and estimate GHG emission projections. All three of these tools are free to use.

CURB – Climate Action for Urban Sustainability. CURB is a climate action planning tool developed by the World Bank Group that helps cities prioritize low-carbon investments based on cost, feasibility, and impact on energy use and GHG emissions[29]. CURB allows cities to plan across six sectors in an integrated way: private buildings, municipal buildings and public lighting, electricity generation, solid waste, transportation, and water and wastewater[29]. CURB version 2.1 was used to project GHG emissions from 2019 levels to 2025, 2030, and 2050 as well as setup a tool for climate action planning strategies.

Local Government GHG Inventory Tool. The US Environmental Protection Agency (EPA) developed the Local Greenhouse Gas Inventory Tool (LGGIT) to help communities across the US evaluate their GHG emissions[30]. The tool's February 2020 update was used to compile two GHG inventories for the entire community and for local government operations. The interactive spreadsheets calculated GHG emissions for many sectors (*i.e.,* residential and commercial) and sources (*i.e.*, transportation and wastewater management). The tool is pre-programmed with default emission factors and system assumptions needed to calculate emissions, but municipality-specific information may be entered.

Waste Reduction Model. The EPA created the Waste Reduction Model (WARM) to help solid waste planners and organizations track and voluntarily report GHG emissions reductions, energy savings, and economic impacts from several different waste management practices[31]. WARM version 15 was used to calculate GHG emissions from waste generation in Concord.

Social Justice Impact

In addition to conducting GHG inventories, the UNH Sustainability Fellow was tasked with considering the social justice impact of her work. Sustainability work at its core is rooted in social justice because environmental problems, such as pollution and climate change, have disproportionately impacted low-income and other vulnerable populations. This GHG inventory considered how vulnerable populations may be affected by any emissions reduction strategies produced from its findings. To approach this objective, we held conversations with community leaders in Concord to get a better picture of social justice issues related to energy. We hope any reduction recommendations we propose will benefit vulnerable populations in addition to the whole community.

Collecting Data by Emission or Removal Source

Collecting data. To account for GHG emissions in Concord, we collected emission and removal data from various sources. From City employees to public utilities, we called, emailed, and "Zoomed" several people for information on activities within the City government and Concord community. Data for several emission and removal sources were collected and prepared to be used in EPA LGGIT and standalone GHG emission and removal calculations (**Figure 3.2**). Eight sources were accounted for in the LGO inventory, and ten sources were accounted for in the community-wide inventory.

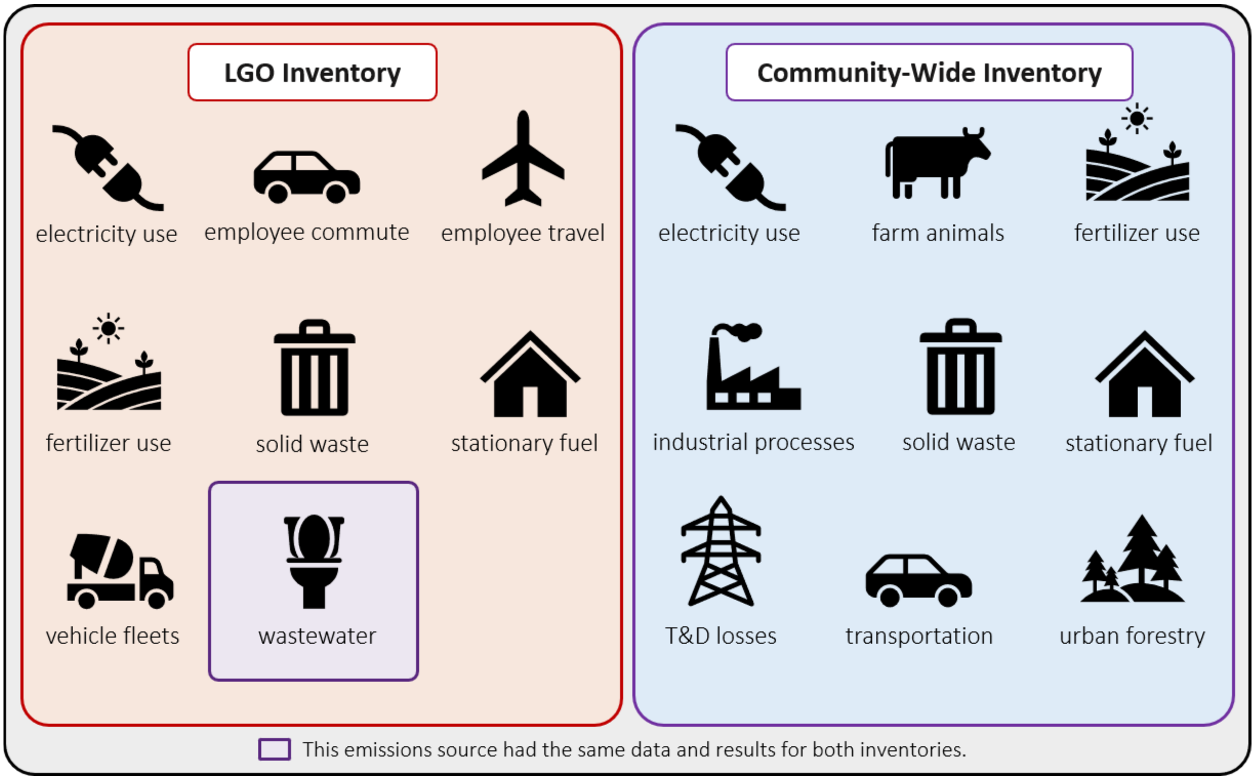

Figure 3.2: Greenhouse gas emission and removal sources included in each inventory. Wastewater treatment is explained in the Local Government Operations (LGO) Inventory, but also included in the Community-Wide Inventory emissions total. T&D is transmission and distribution.

Including farms and schools. In the Community-Wide Inventory, we specifically requested data from farms and schools in Concord, NH. We reached out to several farms in Concord, NH for farm animal and fertilizer use data. There are nine farms in Concord. These farms mainly grow fruits and vegetables. One farming operation provides composting services to residents and businesses in Concord and surrounding cities and towns. Another farm raises dairy cows in addition to growing produce.

We also reached out to the public schools and one private school in Concord, NH, for stationary fuel consumption, electricity consumption, transportation data, and fertilizer use data. There are two school districts in Concord: the Concord School District (CSD) and the Merrimack Valley School District (MVSD). The CSD consists of seven school buildings and two associated facilities. The schools in the CSD are the Abbot-Downing School, Beaver Meadow School, Broken Ground School, Christa McAuliffe School, Concord High School, Mill Brook School, and Rundlett Middle School. The Concord Regional Technical Center is within the Concord High School grounds. The associated facilities in the CSD include the Central Office SAU #8 building and Eastman. The schools in the MVSD within community boundaries are the Merrimack Valley High School, Merrimack Valley Middle School, Merrimack Valley Learning Center, and the Penacook Elementary School. We also reached out to one private school, Saint Paul's School.

The setup. The following information on collecting data, calculating emissions, and addressing challenges and limitations is categorized by the sections of each inventory. The inventory the data were collected for is in parentheses: LGO for "local government operations" and community for "community-wide". All emissions and removals except for wastewater treatment were calculated in EPA LGGIT and standalone Excel files located in the EEAC's Concord Renewable Energy Goal Dropbox cloud storage. Wastewater treatment was only calculated in EPA LGGIT, but the estimations of the populations served by the wastewater treatment plants and domestic septage tanks are in a standalone Excel file. Tree cover from community forests was not considered at the local government operations level, but forests were considered in the **Community-Wide Inventory**.

City Facilities (LGO)

City facilities include airports, athletic courts, community centers, office buildings, warehouses, wastewater treatment plants, and other facilities and infrastructure owned or operated by the City of Concord government. These are stationary buildings or structures that use energy. We also included crosswalk signals, streetlights, and traffic signals in facilities. Stationary fuels and electricity are consumed in City facilities.

Collecting stationary fuel consumption data. According to General Services, natural gas is the only stationary fuel used City facilities. To collect data on City natural gas consumption, we reached out to the natural gas distributor in Concord, Liberty Utilities. Liberty Utilities provided aggregated natural gas consumption used by the municipality for each month in 2019. We also reached out to the City Finance department for more in-depth data, and Brian LeBrun, the Deputy City Manager in Finance, provided available Liberty Utility billing records for each City account number, meter number, and service address.

Collecting electricity use data. To collect data on electricity use in City facilities, we reached out to the electricity distributor in Concord, Unitil. Unitil provided aggregated municipal electricity usage per month from July 2017 to December 2019. However, this aggregated amount for municipal government included the City of Concord government, public schools, public housing, and state government within Concord boundaries. To parse out the City government only, we reached out to Beth Greenblatt and Constellation for the total amount of electricity offset by renewable energy certificates (RECs). The City offsets 100% of their electricity use with these energy certificates, so the total amount of electricity consumed is equal to the total number of RECs.

We also received electricity usage broken down by City account number, meter number, and service address from Unitil. Unfortunately, only the City account number, meter number, and short description of each record identified the electricity usage. We asked Brian LeBrun for more information on the Unitil accounts (*i.e.*, service addresses), and we matched the records to City facilities at each address to our best ability.

Purchasing green energy. *In 2019, the City of Concord government purchased 10,473 megawatt-hours (MWh) of electricity in the form of renewable energy certificates (RECs).* These RECs cost a unit price of about $0.90 per MWh or a total of $9,426 for the year.

Renewable energy resources are essential to the fight against climate change, and these purchases represent bold and committed leadership[26]. The City's RECs were purchased through their energy supplier, Constellation. RECs are market-based instruments that represent the property rights to the environmental, social, and other non-power attributes of renewable electricity generation[32]. The City's RECs are sourced from 100% wind through the NewMix® Wind product (100% National Wind). All the City's electricity requirements under contract are Green-e® certified. Green-e® is a global certification program that makes it easy for businesses, individuals, and local governments to purchase verified clean energy. To make sure the full picture of GHG emissions are accounted for, REC purchases cannot be deducted from Scope 2 emissions (*i.e.*, electricity use) because doing so would constitute double counting[26].

Considering power lines. Some electricity is lost during the transmission and distribution of power from electric generators to end-users. The lost electricity is called transmission and distribution (T&D) losses, where energy converts into heat and dissipates into conductors and transformers during transmission. T&D losses were not considered in this inventory because these losses should be reported by the entity that owns or controls the power lines and not by the end-user of the power[26]. According to the City Finance department, the City does not own or operate the power lines. T&D losses were accounted for in the **Community-Wide Inventory**.

Calculating emissions. To calculate the GHG emissions associated with natural gas combustion, the following equation was used in EPA LGGIT (**Eq. 3.1**):

$$Emissions = \sum_{i=GHG\ gas}^{n=3} consumption \times EF_i \times \frac{MT}{kg} \times GWP_i$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Consumption (mcf):	The natural gas consumption in thousand cubic feet (mcf)
Emissions factor (EF; kg/mcf):	The emissions factor for CO_2 is 54.5; CH_4 is 0.005; N_2O is 0.0001
Metric tons/kilogram (MT/kg):	A unit conversion of 0.001
Global warming potential (GWP):	The global warming potential for CO_2 is 1; CH_4 is 25; N_2O is 298

To calculate the GHG emissions associated with electricity use, the following equation was used in EPA LGGIT (**Eq. 3.2**):

$$Emissions = \sum_{i=GHG\ gas}^{n=3} Billed\ kWh \times \frac{MWh}{kWh} \times EF_i \times \frac{MT}{lb} \times GWP_i$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Billed kwh (kWh):	The electricity use in kilowatt-hours (kWh)
Emissions factor (EF; lb/MWh)[33]:	The emissions factor for CO_2 is 522; CH_4 is 0.08; N_2O is 0.01
Metric tons/pound (MT/lb):	A unit conversion of 0.00045
Global warming potential (GWP):	The global warming potential for CO_2 is 1; CH_4 is 25; N_2O is 298

Each electricity use emissions factor may be different for different years. The ones above are for 2019.

Limitations and future considerations. With both the provided natural gas consumption and electricity use, the facility names were not available. The consumption and usage data were defined by the account number, meter number, and service address. Using the City of Concord Interactive GIS Viewer, Find A Facility application, and provided list of government-owned or operated building from the Assessing division, we matched facility names to service addresses and account numbers to our best ability. Not all service addresses had a street number or usable street address.

In addition to matching uncertainty, the aggregated totals for natural gas consumption and electricity use in City facilities did not equal the summed amounts of data by each account and meter number. After discussing the electricity use discrepancy with our Unitil contact, Gary Miller, we know the aggregated amount for electricity use in the municipal government includes the City of Concord government, public schools, public housing, and state government. The commercial and industrial buildings and residential areas are accurate. Using the total amount of RECs purchased by the City through Constellation, we knew the total amount of electricity used by City government. We can subtract that amount by the municipal aggregated amount to get the aggregated amount of electricity used by public institutions and state government.

Furthermore, the electricity use data by account for the City of Concord government has duplicates within the data due to meter and billing record complications in Unitil's database. For the purpose of exploring the largest electricity users within City government, we removed the duplicates to our best ability. To remove duplicates, we counted the duplicated number of days each record was billed for (*i.e.*, 30 days or 33 days). The number of days with counts the same as or higher than 200 were included in this inventory. The City does own commercial and residential accounts, in addition to municipal accounts. All accounts billed to the City were included in this inventory.

The aggregated amount of natural gas consumption provided by Liberty Utilities does not equal the summed amounts of data by each account and meter number provided by the City government. We tried to sum the broken down data with the natural gas consumption provided by the Concord School District to see if it is the same case the electricity data—where the municipal category includes City government, public schools, public housing, and state government. However, their summation exceeded the aggregated amount. For this inventory, we assumed the aggregated amount was for City government only. *Further communication with Liberty Utilities is highly recommended to sort out this discrepancy.*

Refrigerant leakage and fire suppressant emissions were not considered in this inventory. Many chemicals commonly used in refrigeration, fire suppression equipment, and other products can contribute to global warming. Through the installation, use, and disposal of these systems and products, leaks are likely to occur. While leakage from refrigeration systems may not seem like a large source of GHG emissions, some of these compounds have high Global Warming Potentials (GWPs), and thus even small fugitive emissions can translate into significant emissions in terms of CO_2e.

To account for fugitive emissions in a future update of this inventory, Section 6.6 in the LGOP should be followed[26]. First, you need to identify the refrigerants that consist of the compounds of GHGs in LGOP Appendix E. If the local government uses fire suppression equipment, including hand-held fire extinguishers, the hydrofluorocarbon (HFC) emissions released must be accounted. Only the compounds listed in Table E.1 and Table E.2 should be included. The recommended steps in LGOP Section 6.6 include[26]:

1. Determine the base inventory for each HFC in use at each facility;
2. Calculate changes to the base inventory for each HFC based on purchases and sales of HFC and changes in total capacity of equipment; and
3. Calculate annual emissions of each type of HFC, convert to units of CO_2e, and determine the total HFC emissions for each facility.

Employee Commute (LGO)

City governments can often influence emissions associated with employee commuting to work through various programs (*i.e.*, carpools and flex schedule options) despite not having direct control over them.

Collecting employee commute data. To collect data on City of Concord staff commuting habits, we administered a survey among all City staff. The survey administered was as follows:

"Hello and thank you for filling out the Employee Commute Survey. Your answers will help the City analyze greenhouse gas emissions in Concord and explore actions the city can take to be more sustainable and efficient. Please consider your answers for the year 2019. Please fill out this survey by June 19, 2020 at 5:00 PM."

1. At which department do you work? Choose one:
    - Assessing
    - City Clerk
    - Code Administration
    - Community Development
    - Engineering
    - Economic Development
    - Finance and Purchasing
    - Fire Department
    - General Services (Public Works)
    - Human Resources
    - Human Services
    - Information Technology
    - Legal
    - Library
    - Parks and Recreation
    - Planning
    - Police
    - Administration
    - Other (please specify below)
2. If you chose "Other" in the above question, please specify the department:
3. How do you commute to work every day? Please choose your most used mode of transportation (*Mark only one oval*):
    - Single occupancy vehicle
    - Carpool
    - Motorcycle
    - Transit
    - Bike
    - Walk
    - Work at home
    - Other (please specify below)
4. If you chose "Other" in the above question, please specify the mode of transportation:
5. If you usually drive alone (*i.e.*, single occupancy vehicle or motorcycle), which of the following commute alternatives would you consider using at least one day per week? Please check all that apply (*Check all that apply*):
    - Carpool

- o Vanpool
- o Transit
- o Bike (on-street motorcycles and scooter excluded)
- o Walk

6. How far do you commute to work? Please enter a number (one-way distance in miles):
7. How many days did you work in 2019? Please enter a number:

Once the questions were proofread, we created the survey through Google Forms. The director of Human Resources, Jennifer Johnston, emailed the Google survey link to all City employees. The survey was open for one week (June 12 to June 19, 2020) and included one reminder email sent a day before closing.

Jennifer also provided City active staff counts and associated department and division data a couple days after the survey was administered. The active staff counts include fulltime, part-time, and temporary employees. Unfortunately, not every department included in the survey is a listed department by Human Resources. The survey departments are more closely related to what Human Resources considers "divisions". In addition, Human Resources uses "departments" to break down 14 divisions into 42 smaller categories. To correct this discrepancy, some survey departments were consolidated into one division before tallying the results (**Table 3.1**). Eleven out of thirteen consolidated divisions participated with a total of 155 responses. The overall participation rate was 27%, where the Human Resources and Human Services divisions had full participation by City staff.

Table 3.1: Employee commute survey statistics

Consolidated Division[a]	**Participating City Staff**	**Active Staff**[c]	**Participation Rate**
-	-	-	%
Assessing	4	9	44
City Clerk	0	4	0
Community Development[b]	25	41	61
Finance and Purchasing	11	19	58
Fire Department	24	102	24
General Services (Public Works)	37	129	29
Human Resources	4	4	100
Human Services	4	4	100
Information Technology	0	7	0
Legal	2	10	20
Library	10	30	33
Parks and Recreation	12	88	14
Police	22	122	18
Total	155	569	27

This survey was administered in summer 2020. [a]The departments included in the survey do not completely match the divisions provided by Human Resources. To address this discrepancy, some departments were consolidated into one division. [b]Community Development includes Administration, City Manager, Code Administration, Engineering, and Planning. [c]The active staff count was provided in the summer of 2020 by Human Resources. This count includes fulltime, part-time, and temporary employees.

Most of the participants chose single occupancy vehicle as their main mode of transportation to work (92%; 143 out of 155 responses) [**Table 3.2**]. The second popular mode of transportation was walking, but only a few participants chose this mode (3.9%; 6 out of 155). Out of the other sustainable choices, only one participant used transit, two participants biked, and no participants carpooled.

Table 3.2: Summary of selected modes of transportation

Mode of Transportation[a]	**City Staff Selection**	**Usage**
-	-	%
Bike	2	1.3
Carpool	0	0
Motorcycle	2	1.3
Single occupancy vehicle[b]	143	92
Transit	1	0.6
Walk	6	3.9
Work at home	1	0.6
Other	0	0

[a]City staff were asked to choose their most used mode of transportation to travel to work. This option does not consider staff who have two or more modes of transportation. [b]A single occupancy vehicle can be a passenger car, truck, SUV, or other mode of transportation used by one person, excluding bikes and motorcycles.

Calculating emissions. The proportion of City staff using each mode of transportation was applied the total number of City staff across each division to calculate the total amount emissions from employee commuting. To calculate the GHG emissions associated with employee commuting, the following equation was used in EPA LGGIT (**Eq. 3.3**):

$$Emissions = staff \times MU \times TD \div \frac{people}{mode} \div \frac{miles}{gallon} \times EF \times \frac{MT}{kg} \times GWP\ CO_2 \times \frac{2\ trips}{day} \times workdays$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Staff or employees (count):	The total number of active staff
Mode used (MU; %):	The percent of staff using the mode of transportation
Trip distance (TD; miles):	The average one-way commute length
People/mode:	The number of staff using each mode of transportation
Miles/gallon:	The miles per gallon of each mode of transportation
Emissions factor (EF; kg CO_2/gal):	The emissions factor for each mode of transportation
Metric tons/kilogram (MT/kg):	A unit conversion of 0.001
Global warming potential (GWP):	The global warming potential for CO_2 is 1

Trips/day:	The number trips made to and from work
Workdays (days/year):	The median number of workdays in 2019

When calculating the GHG emissions associated with employee commuting, we used the median workdays per year (240 days) because this number is closer the national average and less affected by outlier answers. Outlier answers may include participants with a low number of workdays in 2019, *i.e.*, part-time or temporary employees. However, including part-time and temporary staff is important because they are still City staff. If we used the average workdays per year (212 days), the total GHG emissions released by employee commuting were 1,222 MT CO_2e in 2019.

Limitations and future considerations. To correct for the department and division survey complications, the first question should be amended to two questions, where the participant can choose multiple answers:

- At which division do you work?
- At which department do you work?

In addition to those questions, the fifth question should be amended to include the following answers, where the participant can choose all answers that apply:

- If you usually drive alone (*i.e.*, single occupancy vehicle or motorcycle), which of the following commute alternatives would you consider using at least one day per week? Please check all that apply (*Check all that apply*):
    - Carpool
    - Vanpool
    - Transit
    - Bike (on-street motorcycles and scooter excluded)
    - Walk
    - I do not know
    - I prefer not to answer
    - I already use an alternative mode of transportation
    - I cannot use an alternative mode of transportation

Making these corrections will clear up confusion from the City of Concord website which lists division different than the tracking done by Human Resources. The amended survey should include the following questions and options:

1. At which division do you work? Choose all that apply:*
    - Assessing
    - City Clerk
    - City Manager
    - Community Development
    - Finance and Purchasing
    - Fire Department
    - General Services (Public Works)
    - Human Resources
    - Human Services
    - Information Technology
    - Legal

    - Library
    - Parks and Recreation
    - Police
    - Other (please specify below)
    - I do not know
2. If you chose "Other" in the above question, please specify the department:
3. At which department do you work? Choose all that apply:*
    - List of 42 departments provided by Human Resources
    - Other (please specify below)
    - I do not know

    OR
    - Have short open answer
4. If you chose "Other" in the above question, please specify the department:
5. How do you commute to work every day? Please choose your most used mode of transportation (*Mark only one oval*):*
    - Single occupancy vehicle (*i.e.*, car, pickup truck, SUV)
    - Carpool or Vanpool
    - Motorcycle
    - Transit
    - Bike
    - Walk
    - Work at home
    - Other (please specify below)
6. If you chose "Other" in the above question, please specify the mode of transportation:
7. If you usually drive alone (*i.e.*, single occupancy vehicle or motorcycle), which of the following commute alternatives would you consider using at least one day per week? Please check all that apply (*Check all that apply*):*
    - Carpool or Vanpool
    - Transit
    - Bike (on-street motorcycles and scooter excluded)
    - Walk
    - I do not know
    - I already use an alternative mode of transportation
    - I cannot use an alternative mode of transportation
8. How far do you commute to work? Please enter a number (one-way distance in miles):*
9. How many days did you work in _*inventory_year*_? Please enter a number:*

The questions marked with an asterisk (*) should be required.

Another way to closely track employee commuting behavior changes is to ask what mode of transportation is used for each day of the work week (Monday to Friday).

Employee Business Travel (LGO)

Employee business travel includes commuting for conferences, workshops, and other work-related events.

Collecting business travel data. To collect data on City of Concord business travel, Brian LeBrun of the City Finance department provided a summary of travel reimbursement. This summary included the travel mileage in dollars. Vehicle miles were estimated at $0.58 per mile. Virtually all business travel was done by car.

Calculating emissions. To calculate the GHG emissions associated with employee business travel, the following equation was used in EPA LGGIT (**Eq. 3.4**):

$$Emissions = vehicle\ miles\ \div \frac{miles}{gallon} \times\ EF \times GWP\ CO_2 \times \frac{MT}{kg}$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Vehicle miles	The total number of miles travelled
Miles/gallon:	The miles per gallon of car travel (21.6 MPG)
Emissions factor (EF; kg CO_2/gal):	The emissions factor for car travel (8.78 kg CO_2/gal)
Metric tons/kilogram (MT/kg):	A unit conversion of 0.001
Global warming potential (GWP):	The global warming potential for CO_2 is 1

We estimated fuel consumption for each consolidated division with an average car travel of 21.6 miles per gallon. Since EPA LGGIT does not have an "Employee Business Travel" section, the calculated fuel consumptions were entered in the "Mobile Combustion" section as the "Passenger Car" vehicle type and "Gasoline" fuel type.

Fertilizer Use (LGO)

Collecting fertilizer data. To collect data on fertilizers applied to City land, we asked Parks and Recreation for fertilizer applied to the different types of land they oversee. David Gill, the director of Parks and Recreation, provided data on the City parks. Sid Chase, the golf course manager, provided data on the Beaver Meadow Golf Course. The City applies synthetic fertilizers to the grounds of the golf course and the athletic fields in the parks.

Calculating emissions. To calculate the GHG emissions associated with fertilizer use, the following equation was used in EPA LGGIT (**Eq. 3.5**):

$$\begin{aligned} Emissions = [(&fertilizer \times \%N \times (1 - \%N\ lost) \times \%N\ applied) \\ &+ (fertilizer \times \%N \times \%N\ lost \times \%N\ volatized) \\ &+ (fertilizer * \%N * (1 - \%N\ lost) * \%N\ leached * \%leached)] \times \frac{MT}{ST} \times \frac{N_2O}{N_2O\ as\ N} \\ &\times GWP_{N_2O} \end{aligned}$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Fertilizer (short tons of N):	The total amount of fertilizer used on City lands
Nitrogen content (%N):	The percent of nitrogen in fertilizer (1)
%N lost:	The percent of nitrogen lost to volatilization (0.1)
%N applied:	The percent of nitrogen applied (0.0125)
%N volatized:	The percent of nitrogen volatized (0.01)
%N leached:	The percent of nitrogen from leach and runoff (0.3)

%leached:	The percent from leached and runoff nitrogen (0.025)
Metric tons/short ton (MT/ST):	A unit conversion of 0.91
Global warming potential (GWP):	The global warming potential for N_2O is 298

All percentages mentioned are for synthetic fertilizer.

Solid Waste Generation (LGO & Community)

Collecting solid waste data. To collect data on waste generated in Concord, NH, we reached out to the Administration Division Manager of General Services, Adam Clark. He provided aggregated data on waste that was landfilled and recycled for the residential and municipal sector and the commercial and industrial sector. Concord sends their waste first to a transfer station in Allentown, NH, and then to a 51-acre Casella Waste Systems landfill in Bethlehem, NH, called the NCES landfill. In 2013, a landfill based geothermal heating system was developed at NCES, which uses geothermal loops to provide a constant heat source to the maintenance shop and greenhouse on site for local educational programs. NCES is in the process of creating one of the first and largest renewable energy projects by using landfill gas to supply renewable fuel to 90,000 homes and businesses in NH. Concord sends their recyclables first to the Allentown transfer station, and then to a recycling center in Charlestown, NH. Leaf and yard waste are processed in Concord at a City-owned site for composting. This compost then goes to farms and other land-based sights for application.

City landfills. According to General Services, Concord has two closed landfills. The first landfill is closed and capped, which means a cover was placed over the landfill waste. This landfill used to flare its landfill gas, but the gas control system is inactive now. The second landfill is closed, but it was not capped. Landfill gas is not collected or flared at the second landfill. Neither landfill anaerobically digested waste. These landfills closed in the late 1980s. City landfills are not considered in either of the inventories.

Calculating emissions. To calculate the GHG emissions associated with waste generated in Concord, the EPA Waste Reduction Model (WARM) version 15 was used[31]. Since we were not provided detailed information on the types of waste landfilled and recycled, the preset "Mixed MSW", "Mixed Recyclables", and "Yard Trimmings" were used for municipal solid waste (MSW), recycling, and leaf and yard waste. Google Maps was used to find the distance between Concord, NH, and the NCES landfill (about 80 miles). Google Maps was also used to find the distance between Concord, NH, and Charleston, NH (about 60 miles). For composting, a 10 mile-distance was used since the processing facility is in the city. Only the emissions from the landfill were included in each inventory.

Limitations. Only a limited amount of data is available for solid waste generated in Concord. Since the types of waste landfilled and recycled were not provided, a preset mix for municipal solid waste and recyclables was used in EPA WARM. Recycling data was not available for commercial and industrial businesses. In addition, the residential and municipal tonnage was aggregated together. After discussing this aggregation with Adam Clark, we estimated that 5% of this aggregated tonnage was from municipal buildings.

It is possible a small portion of commercial and industrial business waste was excluded from the landfill total—only the businesses following and aware of the Solid Waste Flow Control Ordinance are included (Ord. No. 2960, § I, 6-13-16). The Solid Waste Flow Control Ordinance states that all acceptable waste generated in the city must be sent to a City-designated waste aggregation and transfer facility. The designated facilities include the Allentown Transfer Station located at 104 River Road, Allentown, NH, and (2) the Bestway Transfer Station located at 43 Industrial Drive, Belmont, NH. Sometimes haulers disregard the ordinance, are not registered in the city, or do not know about the ordinance, so the waste they haul does not go to a designated facility.

Vehicle Fleets (LGO)

Vehicle fleets owned or operated by the City include construction equipment, fire vehicles, police vehicles, recreational equipment, and other vehicles used by the City.

Collecting vehicle fleet data. To collect data on City vehicles and equipment used, we reached out to the deputy director of General Services, Jeff Hoadley, for fuel consumption and miles travelled in 2019. Unfortunately, vehicle data only dated back to June 2019. To accommodate for this, we assumed a full year of vehicle and equipment use to be June 1st, 2019, to May 31st, 2020.

From June 2019 to May 2020, 222 vehicles were used by the City, where 48 of them were construction, recreation, or utility equipment. Out of 222 vehicles, 128 of them consumed gasoline (58%), 91 of them consumed diesel (41%), and 2 of them consumed compressed natural gas (CNG) or another fuel (1.4%). Five out of thirteen consolidated divisions (see **Table 3.1** for reference) used City vehicles: (1) Community Development, (2) Fire Department, (3) General Services, (4) Parks and Recreation, and (5) Police.

Calculating emissions. To calculate the GHG emissions associated with City vehicle fleets, the following equation was used in EPA LGGIT (**Eq. 3.6**):

$$Emissions = fuel\ use \times EF \times \frac{MT}{kg} \times GWP_{CO_2}$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Fuel use (gallons or G.G.E.)	The fuel consumed in gallons; or gasoline gallon equivalent
Emissions factor (EF; kg CO_2/gal):	The emissions factor for each fuel type
Metric tons/kilogram (MT/kg):	A unit conversion of 0.001
Global warming potential (GWP):	The global warming potential for CO_2 is 1

Limitations and future considerations. Since we did not have a full year of 2019 data, we estimated a full year from June 1st, 2019 to May 31st, 2020. This estimation will include any changes to mobile vehicles from 2019 to 2020. GHG emissions may be skewed downward from 2019 due to the closing of nonessential businesses due to COVID-19 from March to May 2020.

Fugitive emissions from motor vehicle air conditioning were not included in this inventory. Most on-road vehicles owned and operated by a local government have air conditioning systems. These systems may use refrigerants that contain compounds that should be reported under the LGOP. Through the use and maintenance of these systems, refrigerant leaks are likely to occur.

To collect data for these fugitive emissions, you should refer to LGOP Section 7.4[26]. Hydrofluorocarbons (HFCs) are the primary GHG of concern for motor vehicle air conditioners. The recommended approach includes the following steps[26]:

1. Determine the base inventory for each refrigerant used in your fleet vehicles
2. Calculate changes to the base inventory for each refrigerant based on purchases and sales of refrigerants and changes in total capacity of the equipment

3. Calculate annual emissions of each type of refrigerant, convert to units of CO_2e, and determine the total HFC emissions.

Wastewater Treatment (LGO & Community)

Collecting wastewater treatment data. To collect data on wastewater treatment in Concord, we reached out to the wastewater treatment plant superintendent, Dan Driscoll. The City of Concord owns and operates two wastewater treatment plants (WWTPs): (1) the Hall Street Wastewater Treatment Facility and (2) the Penacook Wastewater Treatment Facility (**Table 3.3**). The wastewater collection system contains 163 miles of sanitary sewer line and 8 pump stations throughout Concord[34]. Along with Portsmouth, NH, Concord is one of two communities in New Hampshire that operates two WWTPs.

The main WWTP is the Hall Street WWTP. Built in 1979, this plant provides wastewater treatment for Concord and portions of Bow, NH. The plant performs biosolids dewatering and stabilization, processing about 7,500 wet tons of biosolids annually—100% of the city's biosolids get transported off-site to be used for compost or agricultural purposes. The plant occupies 28 acres of land surrounded by an additional 75 acres of wooded area and farmland.

The second WWTP is the Penacook WWTP, which provides wastewater treatment for Penacook Village and a portion of Boscawen, NH. Built in 1973, this plant originally treated industrial discharge from a leather tannery. After the tannery closed in 1987, the flow reduced. In 2005, the plant was converted from a conventional activated sludge plant to a sequencing batch reactor (SBR) process.

Table 3.3: Summary of Hall Street and Penacook WWTP operations

	Hall Street	**Penacook**
Year Built	1979	1973 (converted 2005)
Population Served (residents)	32,000[b]	3,700[c]
Cities Served	Concord, Bow	Penacook, Boscawen
Average Flow (mgd)[a]	4.0	0.40[c]
Design Flow (mgd)	10	1.2
Peak Flow (mgd)	25	5.5

Penacook is a village in Concord, NH. [a]mgd = million gallons per day. [b]This population has been estimated; see **Table 3.4**. [c]This population was recorded in the September 2016 issue of Treatment Plant Operator Magazine[35].

Calculating emissions. To calculate GHG emissions associated with wastewater treatment, EPA LGGIT asks a series of questions that we provided to the WWTP superintendent:

1. What is the total population served by the WWTPs? How many are from Concord, NH?
    a. *Unanswered.*
2. Does Concord have one or more facilities where wastewater is treated in ***anaerobic*** conditions? Which one(s)?
    a. *None of the facilities have anaerobic processes.*
3. Does Concord have one or more facilities where wastewater is treated in **aerobic** conditions? Which one(s)?
    a. *Both Hall Street and Penacook use an aerobic treatment process.*

4. Do one or more centralized wastewater treatment plants in Concord ***not conduct*** nitrification/denitrification? Which one(s)?
    a. *Hall Street nitrifies, but it does not denitrify. Penacook will enter the nitrification process during the summer months due to the nature of the process, but it is not required by permit. There is no denitrification at Penacook.*
5. Is data available for the treatment systems on both the amount of digester gas produced per day (ft^3/day or volume/time) and the fraction of methane (CH_4) in the biogas?
    a. *No digesters on site at either location.*
6. Is data available for the treatment systems on both the BOD_5 influent to the wastewater treatment process (kg BOD_5/day) and the amount of BOD_5 removed during primary treatment (fraction)?
    a. *Hall Street BOD load is approximately 10,500 pounds/day with approximately 45% removal in the primary clarifier. Penacook influent BOD load is approximately 1,250 pounds per day. There is no primary treatment at the Penacook facility.*
7. Is any portion of the total population served by septic systems?
    a. *Yes.*
8. Is there any industrial nitrogen load into the wastewater treatment systems (kg N/day)?
    a. *No known significant inputs.*
9. Do Concord facilities collect measurements of nitrogen load in the system's effluent discharge to water bodies (average total nitrogen discharged; kg N/day)?
    a. *The city is not required to collect nitrogen data at this time.*

Limitations and future considerations. Unfortunately, the populations served by the WWTPs and septic tanks in Concord were not provided. These populations are needed for EPA LGGIT to estimate GHG emissions. Through various references, we calculated a rough estimate of these populations. In September 2016, the City employees of the Penacook WWTP were featured in an issue of Treatment Plant Operator (TPO) Magazine[35]. In this feature the population of residents served by the Penacook WWTP was recorded (3,700 people). The City of Concord also reports on their government website that the Hall Street WWTP processes about two million gallons of domestic septage from local communities annually[34]. In 1990, the US Department of Commerce Census Bureau estimated the number of housing units with septic tanks or cesspools and the approximate volume of septage generated each year in the US.[36] They found that about 24.6 million people generate about 5.5 billion gallons of septage annually[36]. With these values and the 2018 American Community Survey Five-Year Estimate populations for Concord (43,000 people) and Bow (7,800 people), we estimated the Concord population on septic tanks and the population of Concord and Bow served by the Hall WWTP (**Table 3.4**).

If the population served by each WWTP and the population served by septic tanks can be provided, these emission calculations would be more robust.

Table 3.4: Summary of calculations for wastewater populations

Calculation	Value
Number of housing units with septic tanks in the US[36] =	24,600,000
Gallons of domestic septage generated in the US[36] =	5,500,000,000
Septage generated per housing unit (gallons/unit) =	224
Concord domestic septage volume (gallons)[34,a] =	1,000,000
Number of housing units with septic tanks in Concord[b] =	4,500
People per housing unit in Concord[c] =	2.5
Population on septic tanks in Concord[d] =	11,200
Population served by Hall Street WWTP[e] =	32,000
Population served by aerobic WWTPs[f] =	35,800
Population served by nitrifying WWTPs[f] =	35,800

[a]We assumed 50% of the domestic septage processed at the Hall Street WWTP is from the Concord population. [b]This value is calculated by multiplying the septage generated per housing unit with the Concord domestic septage volume. [c]This value is calculated by dividing the Concord population (43,040 people) by the number of occupied housing units (17,242 units). [d]This value is calculated by multiplying the number of housing units with septic tanks in Concord by the people per housing unit in Concord. [e]This value is calculated by subtracting the Concord population with the population on septic tanks and the population served by the Penacook WWTP (3,700 people) as well as adding the Bow population multiplied by 0.50. 50% of the Bow population is assumed to use the Hall Street WWTP. [f]This value is calculated by adding the populations served by the Hall Street and Penacook WWTPs.

Built Environment (Community)

As defined by the US Community Protocol (USCP), the built environment includes the human-made surroundings that provide the living and working spaces for human activity, ranging in scale from personal shelter and buildings to neighborhoods and cities that include supporting infrastructure, such as energy networks[28]. Greenhouse gas (GHG) emissions attributed to the built environment include those from government or municipal, residential, commercial, and industrial buildings; the operational processes and human activities with those buildings; and electric vehicle use[28]. These emissions are limited to energy used within buildings, refrigerants, fire suppressants, and industrial processes[28].

Collecting stationary fuel data. To collect data on natural gas consumption in the city, we reached out to the natural gas distributor in Concord, Liberty Utilities. Liberty Utilities provided aggregated natural gas consumption used by commercial and industrial buildings, residential buildings, and municipal buildings for each month in 2019.

Collecting electricity data. To collect data on electricity use in the city, we reached out to the electricity distributor in Concord, Unitil. Unitil provided aggregated commercial, industrial, municipal, and residential electricity usage per month from July 2017 to December 2019. Data for the commercial and industrial sectors were added together to act as a single sector. We also received the total electricity usage by the twenty commercial and industrial buildings using the most kilowatt-hours (kWh) each year.

Estimating residential heating fuels. Concord residents and businesses use a variety of heating fuels. Unfortunately, we were unable to collect city data on every heating or stationary fuel. For residential heating fuels other than natural gas (*i.e.*, fuel oil, propane, and wood), we followed the USCP

Method BE.1.2[28]. This method uses 2018 housing unit data from the American Community Survey (ACS) and the 2018 New Hampshire State Profile and Energy Estimates (SEDS) from the US Energy Information Administration (EIA).

Estimating commercial fuel oil. The data available for the commercial sector is more limited than the residential sector, so fuel oil is the only stationary fuel that can be estimated. To estimate commercial and industrial building fuel oil, we followed the USCP Method BE.1.3[28]. This method uses the 2012 Commercial Buildings Energy Consumption Survey (CBECS) from the US EIA and commercial and industrial building information from the City Assessing division.

Is fuel oil widespread in Concord, NH? Before estimating the GHG emission associated with commercial fuel oil use, we conducted a quick Google search for fuel oil companies in Concord to answer this question. We wanted to make sure the estimation was justified. Eight or more fuel oil companies were listed, including AmeriGas, Aranco Oil (two locations), Bill Trombly Plumbing HTG-Fuel Oil, Fred Fuller Oil, Huckleberry Propane and Oil, Irving Energy (three locations), Johnny Prescott and Son Oil, and Rymes Propane and Oil. This list does not include surrounding cities and towns that may be utilized as well.

Estimating industrial processes. In addition to the typical sources of GHG emissions from stationary fuels, a community may also contain industrial operations that contribute significant emissions as byproduct of production and other processes. To estimate industrial processes, we followed the USCP Method BE.8.1[28]. This method uses the US EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT)[37] to include 2018 Mandatory Reporting Rule emissions from reporting facilities.

Estimating transmission and distribution losses. A certain amount of electricity is lost to heat when electricity is transmitted through power lines. These losses are called transmission and distribution (T&D) losses, and they represent a significant portion of the total electricity generation[28]. These indirect GHG emissions should be accounted for in a community-wide inventory because reducing a community's electricity use will also reduce the amount of T&D losses associated with delivering this electricity. In conjunction with collected electricity use data, T&D losses must be estimated. We estimate these losses with the USCP Method BE.4.1[28] and the 2018 Emissions and Generation Resource Integrated Database (eGRID)[33].

New England electricity fuel mix. Electricity used in New England is produced by generators in New England and imported from other regions to satisfy all residential, commercial, and industrial customer demand during 2019 (**Table 3.5**)[38]. This is called the net energy for load (NEL).

Table 3.5[38]: Sources of electricity used in 2019

	Usage	Generation	Net Energy for Load
	GWh[a]	%	%
Total Generation[b]	**97,853**	**100**	**82**
Gas	47,447	48.5	39.9
Nuclear	29,818	30.5	25
Renewables	11,149	11.4	9.4
Wind	3,527	3.6	3
Refuse	3,027	3.1	2.5
Wood	2,476	2.5	2.1
Solar	1,644	1.7	1.4
Landfill Gas	431	0.4	0.4
Methane	44	0.04	0.04
Steam	0	0.0	0.0
Hydro[c]	8,788	8.9	7.4
Coal	442	0.5	0.4
Oil	161	0.2	0.1
Price-Responsive Demand	26	0.03	0.02
Other[d]	21	0.02	0.02
Net Flow over External Ties[e]	**22,985**		**19**
Quebec	14,010		
New Brunswick	3,287		
New York	7,343		
Pumping Load[f]	**-1,717**		**-1.4**
Net Energy for Load[g]	**119,122**		**100**

[a]GWh is gigawatt-hour. [b]As of January 2016, this table approximates the amount of generation by individual fuels used by dual-fuel units, such as natural-gas-fired generations that can switch to run on oil and vice versa. Previously, the report attributed generation from such units only to the primary fuel type registered for the unit. The new reporting flows from changes related to the Energy Market Offer Flexibility Project implemented December 2014. [c]Hydro is not included in the Renewables category primarily because the various sources that make up hydroelectric generation (*i.e.*, conventional hydroelectric, run-of-river, pumped storage) are not universally defined as renewable in the six New England states. [d]"Other" represents resources using a fuel type that does not fall into any of the existing categories. Other may include new technologies or new fuel types that come onto the system but are not yet of sufficient quantity to have their own category. [e]Tie lines are transmission lines that connection two balancing authority areas. A positive value indicates a net import; a negative value represents a net export. [f]The energy used to operate pumped storage plants. [g]Generation plus net interchange minus pumping load.

New Hampshire electric renewable portfolio standard. New Hampshire's renewable portfolio standard (RPS) statute [RSA 362-F] requires each electricity provider to meet customer load by purchasing or acquiring certificates representing generation from renewable energy based on total megawatt-hours supplied. In 2019, the total RPS requirement was 19.70%. This is the minimum percentage of renewable sources required in the energy used to generate electricity.

We used the Northeast Power Coordinating Council (NPCC) New England (NEWE) eGRID subregion emissions factors to calculate the greenhouse gas emissions from electricity use in Concord. Our emissions calculations may be conservative because they use a regional estimate of renewables used to generate electricity.

Calculating emissions. To calculate the GHG emissions associated with natural gas combustion, **Equation 3.1** in the **City Facilities** section was used in EPA LGGIT. Altered to suit different stationary fuel types, **Equation 3.1** can also be used to calculate the emissions from fuel oil, propane, and wood. Residual fuel oil number 5 was used as a proxy to calculate the emissions for commercial fuel oil as well as for the aggregated distillate fuel oil and kerosene consumption in residential buildings.

To calculate the GHG emissions associated with electricity use, **Equation 3.2** in the **City Facilities** section was used in EPA LGGIT. To calculate the GHG emissions associated with T&D losses, the following equation was used (**Eq. 3.7**):

$$Emissions = \sum_{i=GHG\ gas}^{n=3} \frac{electricity\ use \times GGL \times EF_i \times GWP_i}{2204.6}$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Electricity use (MWh):	The electricity consumed by the Concord community
Emissions factor (EF; lb gas/MWh):	The eGRID NEWE emissions factors for electricity[33]
Grid gross loss (GGL; %):	The Eastern grid gross loss factor from eGRID of 4.88%[33]
Global warming potential (GWP):	The global warming potential for CO_2 is 1; CH_4 is 25; N_2O is 298

Limitations and future considerations. Heating fuel data was not normalized by heating and cooling degree days in 2019. See **Figure 2.3** for the monthly New Hampshire heating and cooling degree days in 2019.

The method used to estimate residential heating fuel consumption (USCP BE.1.2) has its limitations. You cannot differentiate between homes that use each fuel source available for primary heat, secondary heat, or simply cooking. These end-uses will have a wide range of actual use. This method also does not include households which use a fuel source for back-up heating, cooking, or other end use, resulting in a smaller total use than may be present. The following assumptions were made with the data available from ACS and SEDS:

- No coal or coke was used for heating fuel because the EIA SEDS estimate for coal was 0 short tons from 2016 to 2018.
- Propane is the only hydrocarbon gas liquid used.
- Propane from SEDS is assumed to be bottled, tank, or liquefied petroleum gas from ACS.
- Since kerosene nor distillate fuel oil is an available option in EPA LGGIT, residual fuel oil number 5 was used as a proxy.

In addition, the commercial fuel oil can be better estimated through a commercial business survey on stationary fuels used in each building.

The method used to estimate industrial processes (USCP BE.8.1) has its limitations. The data available from the US EPA Mandatory Reporting Rule will not provide a complete accounting of all process emissions in Concord. Any facility that emits under the 25,000 MT CO_2e per year threshold will not be among the sources available from EPA FLIGHT. However, it is possible to identify industries in the community that may fall under the EPA reporting threshold and directly request GHG data from them. The EPA publishes a data table of non-GHG pollutant by facility that can be useful in identifying major industries in your community. The National Emissions Inventory Facility Emissions Summaries (NEI) do not contain information about GHGs, but they do show sources of other emissions in your community by North American Industry Classification System (NAICS) code. The NAICS codes will show the type of industry, so if there are cement producers, steel manufacturers, or other likely GHG emitters in your community that fall below the EPA's mandatory reporting threshold for GHGs, you may be able to find them in this data source and contact them directly for information.

After discussing electricity use in Concord with our Unitil contact, Gary Miller, we know the aggregated amount for electricity use in the municipal government includes the City of Concord government, public schools, public housing, and state government. The commercial and industrial buildings and residential areas are accurate. Using the total amount of renewable energy credits (RECs) purchased by the City government through Constellation, we knew the total amount of electricity used by City government. We can subtract that amount by the municipal aggregated amount to get the aggregated amount of electricity used by public institutions and state government. The other institutions were aggregated with the commercial and industrial totals.

Many chemicals commonly used in refrigeration, fire suppression equipment, and other products can contribute to global warming. Through the installation, use, and disposal of these systems and products, leaks are likely to occur. Unfortunately, obtaining accurate data for community refrigerant and fire suppression chemical leakage is challenging. At the community scale, such information will be difficult to collect from all sources as there are potentially thousands of individual applications where these chemicals are used. USCP Method BE.7 provides some guidance on how to start looking for these sources[28].

Farm Animals and Fertilizer Use (Community)

Collecting fertilizer data. To collect data on fertilizers applied to the Concord community, we asked the public school districts (*i.e.*, Concord School District or CSD, Merrimack Valley School District or MVSD), Saint Paul's School, and several farms in Concord to provide data for 2019. Unfortunately, we did not get a great response rate. Only the public school districts, Saint Paul's School, and one farm responded. Interestingly, CSD does not apply fertilizer to the school grounds. Although this data, along with the City fertilizer use, were added to the inventory emissions, these estimates should be interpreted with uncertainty because the dataset is small.

Estimating farm animals. Agricultural livestock activities can be a significant source of GHG emissions for some communities. Many different types of livestock activities can produce emissions. One farm in Concord raises dairy cows. Unfortunately, we were unable to get data animal populations in time for this report. To accommodate for the missing data, we estimated the animal population count from various video interviews (*i.e.*, Granite State Dairy) and website features (*i.e.*, Udderly Amazing Dairy) on the dairy farm. We followed the USCP Methods A.1 and A.2[28]. These methods calculate emissions from enteric fermentation and manure. Enteric fermentation is a digestive process in ruminant animals, such as cattle and sheep. Microbes in the digestive tract, or rumen, decompose and ferment food, producing methane as a by-product.

Calculating emissions. To calculate the GHG emissions associated with fertilizer use, **Equation 3.5** in the City **Fertilizer Use** section was used in EPA LGGIT. To calculate the emissions associated with farm animals, the five equations laid out in the USCP Methods A.1 and A.2 were used[28].

Limitations and future considerations. Since only the schools and one farm provided data on fertilizer use, the full picture is not expressed in the data. A community survey for fertilizer use in commercial business properties, farms, public and private schools, residential areas, and universities would better estimate fertilizer use and its associated emissions. Otherwise, the source should be omitted from the inventory. In addition, a better annual count of the farm animal populations at the dairy farm will provide more robust emissions estimations.

Transportation (Community)

Collecting transportation data. To collect data on transportation in Concord, we requested registered vehicles from Dawn Enwright, the treasurer/tax collector in the City Collections department. We also requested vehicle data from the public schools (*i.e.*, Concord School District or CSD and Merrimack Valley School District or MVSD), one private school (*i.e.*, Saint Paul's School), Concord Area Transit (CAT), and local government fleets. See the **Vehicle Fleets** section for more information on City fleets.

We were provided data on the transit system (Concord Area Transit or CAT) in Concord, NH, from the CAT Transportation Director, Terri Paige. Since 1989, CAT has provided Concord, NH, with public transportation services through an accessible fixed-route service and two demand-response services. Bus fare costs $1.25 for adults, $0.50 for seniors over 60, and nothing for children under 5.

From Dawn Enwright, we received 45,037 records of vehicles registered in Concord in 2019. About 99% (44,717 out of 45,037) of these records had usable data, whereas 320 were empty entries. The 320 empty entries were not included in the calculations. Fifty-three different vehicle codes were categorized into the eight vehicle types found in EPA LGGIT (**Table 3.6**). Most of the registered vehicles were light trucks (21,816 out of 44,717 records; 49%) and passenger cars (16,185 out of 44,717 records; 36%). Light trucks include vans, pickup trucks, station wagons, and SUVs. Vehicle records were also identified as a person or company holding the registration. Over 91% of the records (40,610 out of 44,717 records) were held by a person, whereas 9% (4,107 out of 44,717) where held by a company. Companies were assumed to be in the commercial and industrial sector, and people were assumed to be in the residential sector.

Table 3.6: Summary of 2019 registered vehicles records by vehicle type

		Registration Holder	
Vehicle Type	**Total Vehicles**	**Company**	**Person**[a]
-	Count	Count (%)	Count (%)
Agricultural Equipment	66	1 (2%)	65 (98%)
Construction Equipment	400	176 (44%)	224 (56%)
Heavy-Duty Vehicle	1226	627 (51%)	599 (49%)
Light Truck[b]	21816	2434 (11%)	19382 (89%)
Motorcycle[c]	1866	2 (0%)	1864 (100%)
Passenger Car	16185	427 (3%)	15758 (97%)
Ship or Boat[d]	811	19 (2%)	792 (98%)
Utility and Recreational Equipment	2347	421 (18%)	1926 (82%)
Total	**44,717**	**4,107 (9%)**	**40,610 (91%)**

320 registered vehicle records were not included in this table because they the entries were left blank. This data was retrieved from the City Finance and Purchasing division. [a]By Person includes entries where the registration holder was left blank (1,569 out of 44,717 records). [b]A light truck can be a van, pickup truck, station wagon, or SUV. [c]Motorcycles include mopeds. [d]Ships or boats include all vehicles labelled boat trailer.

Unfortunately, only cars, heavy-duty vehicles, light trucks, and motorcycles were considered in this inventory. We were unable to estimate the fuel consumption from or vehicle miles travelled by agricultural equipment, construction equipment, ships or boats, and utility and recreational equipment. So, 41,093 out of 44,717 (92%) registered vehicles were considered in this inventory (**Table 3.7**). The electric vehicles were already considered in the **Built Environment** section through electricity use. Most registered vehicles used gasoline (95%; 39,106 out of 41,093 records). The 449 hybrid vehicles were assumed to use gasoline as well, increasing the total number using gasoline even more.

Table 3.7: Total number of vehicles by vehicle type and fuel type included in the inventory

Vehicle Type	Diesel[a]	Electric	Gasoline	Hybrid[b]	Other Fuel[c]	Total
Light Truck[d]	399	2	21303	108	4	**21,816**
Heavy-Duty Vehicle	1025	0	201	0	0	**1,226**
Motorcycle[e]	0	0	1865	0	1	**1,866**
Passenger Car	57	46	15737	341	4	**16,185**
Total	**1,481**	**48**[f]	**39,106**	**449**	**9**	**41,093**

[a]Some heavy-duty vehicles were labelled with a “Trailer” fuel type (561 out of 1226 records). These vehicles were assumed to use diesel. [b]Hybrid vehicles were assumed to use gasoline. [c]Other fuel types include coal, methane, oil, and propane. [d]A light truck can be a van, pickup truck, station wagon, or SUV. [e]Motorcycles include mopeds. [f]Five electric vehicles are not included in this total number from the registered vehicles data because they were construction equipment.

Calculating emissions. To calculate the GHG emissions associated with transportation, **Equation 3.6** in the **Vehicle Fleets** section was used in EPA LGGIT. Average annual vehicle miles travelled (VMT) were estimated from the NH Department of Transportation's (DOT) 2018 report and the NH Department of Safety (DOS) Division of Motor Vehicles' (DMV) 2018 On-Board Diagnostics report. The NH DOT estimated that vehicles in NH travelled 14 billion miles in 2018. The NH DOS DMV estimated there were 1.8 million registered vehicles in NH in 2018. We used these numbers to create a conversion factor from total number of registered vehicles to total number of vehicle miles travelled in Concord (7,653 average VMT per NH vehicle per year).

Another option to estimate annual VMTs was the "Average Annual Fuel Use by Vehicle Type" chart from the US Department of Energy's Alternative Fuels Data Center (**Table 3.8**)[39]. We could have averaged the VMTs of the Class 8 Truck, Transit Bus, Paratransit Shuttle, Refuse Truck, Delivery Truck, and School Bus to get an estimated heavy-duty vehicle VMT (30,877 average annual VMT). However, these numbers were much higher the 2018 average annual VMT per NH vehicle, so we opted to not use those values.

Table 3.8: Average annual miles travelled by vehicle type

Vehicle Type	Annual Vehicle Miles Travelled
Class 8 Truck	62,751
Transit Bus	43,647
Paratransit Shuttle	29,429
Refuse Truck	25,000
Delivery Truck	12,435
School Bus	12,000
Light Truck/Van	11,543
Car	11,467
Motorcycle	2,312

This chart was sourced from the US Department of Energy's Alternative Fuels Data Center[39].

Limitations and future considerations. It is possible the public school districts, private school, and local government fleets were double counted in the registered vehicles and standalone data sources. We included both sets of data because the standalone sources had more robust emissions estimates than the registered vehicles. Also, construction, recreation, and utility equipment would be included at the local government scale. We were unable to estimate fuel consumption or vehicle miles travelled by agricultural equipment, construction equipment, ships and boats, and utility and recreational equipment provided in the registered vehicles data.

In addition, companies, especially small businesses, may register vehicles in a person's name but use the vehicle for company purposes. These companies will be accounted for in the residential sector because we are assuming all person registration holders are residents (or temporary residents). Records with an unknown (blank) registration holder were assumed to be people or residents.

Furthermore, looking at registered vehicles does not tell us much about the usage of those vehicles. Concord residents may have a registered vehicle, but bike, walk, or use transit more than their single occupancy vehicle. Future consideration should explore the mode of transportation choices by residents.

Urban Forestry (Community)

The Arbor Day Foundation named Concord a Tree City USA community in honor of the city of Concord's dedication to forestry management. The City General Services' Sustainable Street Tree program is one of many ways the City invests in the community's urban forestry. *The City plants approximately 25-30 trees a year within approved locations. In 2019, 50 trees were planted, totaling to 279 trees planted overall.*

Collecting forestry data. To collect data on tree cover in Concord, we explored the 2018 New Hampshire Town and Community Forests Study[40]. The University of New Hampshire Cooperative Extension, the Northern Forest Center, and the New Hampshire Association of Conservation Commission (NHACC) conducted a multi-year study to inventory town-owned forests and quantify the economic, ecological, and social contributions they make locally and to the state[40]. The study included land that is (1) owned by a municipality or other local government entity such as a school district or a water district, (2) 10-acres and greater, (3) a combination of forest, field and wetland, and (4) not slated for future development[40].

Calculating removals. To calculate the GHG emissions removed by carbon sequestration in community forests, the following equation was used (**Eq. 3.8**):

$$Emissions = tree\ area \times \frac{hectare}{km^2} \times CSF \times \frac{CO_2}{C} \times GWP_{CO_2}$$

Where

Emissions (MT CO_2e):	The 2019 GHG emissions
Tree area (km^2):	The forest area in the community
Hectare/kilometers:	The unit conversion of 100
Carbon sequestration factor (CSF; MT C/hect/yr):	The sequestration factor for trees
CO_2/C:	The moles of CO_2 over the moles of C is 3.67
Global warming potential (GWP):	The global warming potential for CO_2 is 1

Limitations and future considerations. How lands are managed, from forest conservation to agricultural practices, can affect the exchange of GHGs between the atmosphere and land. Land use can result in GHG emissions, but it also can lead to removals of CO_2, mostly into forests and trees. The net effect of land use is estimated based on the change in carbon stocks, or stores of carbon in biomass, litter, dead wood, and soils. In addition to forestry, other land uses should be considered. The USGS National Land Cover Database is a great resource to start with as it has land use change from 2001 to 2016[41]. Also, the USCP Appendix J provides some guidance on including land use and management in GHG inventories[28].

4. Local Government Operations Inventory

Results

Overview

In 2019, we estimated that the City of Concord's local government operations (LGO) released 12,049 metric tons of carbon dioxide equivalent (MT CO_2e) in greenhouse gas (GHG) emissions. In this inventory, we explored emissions from eight different sources under operational control (**Figure 3.2**). Stationary fuel caused over a quarter of the emissions released by local government operations (27%; 3,265 out of 12,049 MT CO_2e). In addition, wastewater treatment (26%) and electricity use (21%) were the second and third biggest emission sources in 2019 (**Figure 4.1**). Solid waste generation, employee business travel, and fertilizer use barely contributed 2% to the total amount of emissions (2.1%; 256 out of 12,049 MT CO_2e).

When exploring emissions reduction strategies, the City should focus on reducing energy use in facilities, starting with the Hall Street and Penacook Wastewater Treatment Plants (WWTPs), the Water Treatment Plant (WTP), Combined Operations Maintenance Facility (COMF), and the Douglas N Everett Ice Arena. Reducing electricity use in all City facilities will reduce the amount of renewable energy certificates the City buys to offset the fossil fuels used to generate its electricity. Furthermore, the City should focus on reducing transportation emissions from vehicle fleets and employees commuting to work.

The setup. The following sections are in alphabetical order:

1. City Facilities (including stationary fuels and electricity use)
2. Employee Commute and Business Travel
3. Fertilizer Use
4. Vehicle Fleets
5. Solid Waste Generation
6. Wastewater Treatment

The same wastewater treatment results were used in both the LGO and community-wide inventories. This action is because the City owns and operates the treatment plants, so the emissions from the Concord community are included in both inventories. When differentiating between the local government and community, "City" will be used for the Concord government, and "city" will be used for the Concord community.

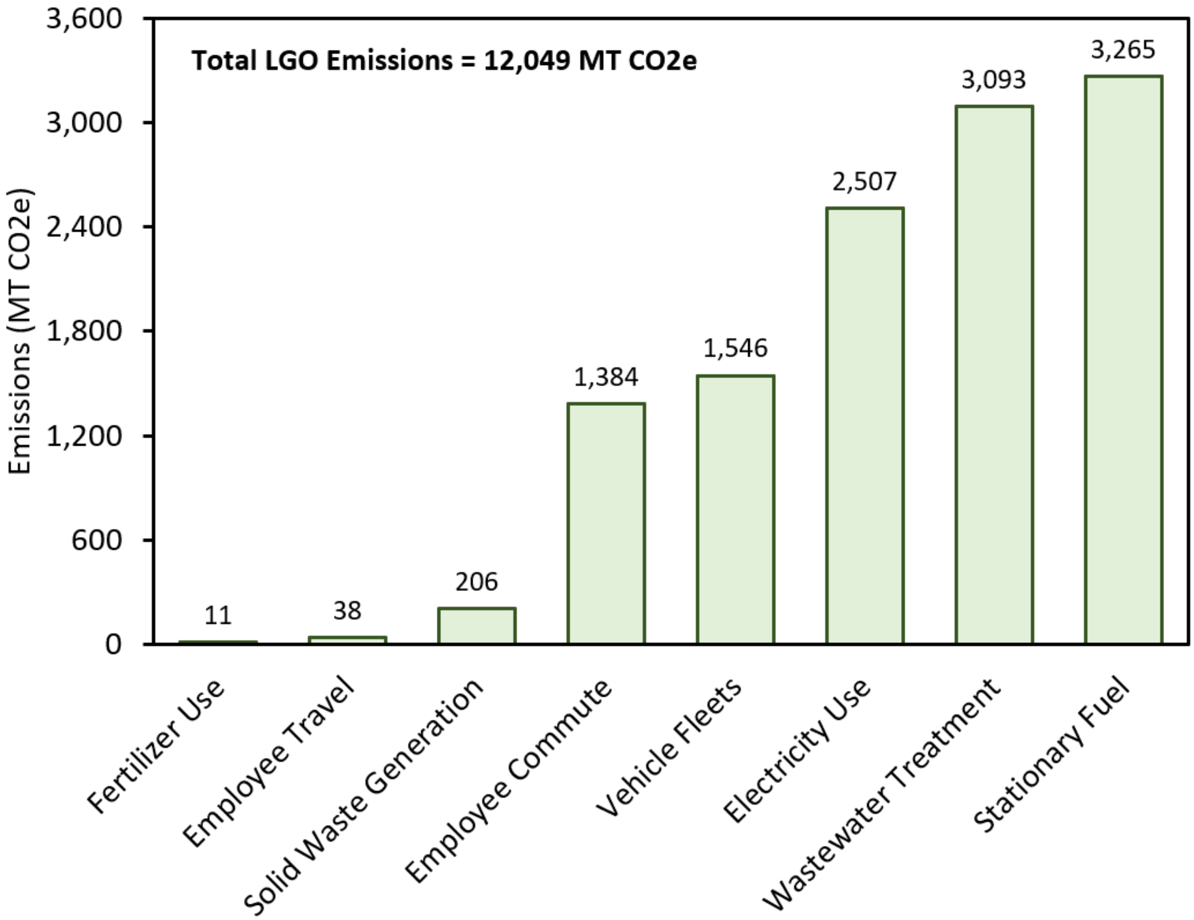

Figure 4.1: Estimated greenhouse gas emissions (MT CO_2e) emitted by each local government operations source in 2019. The number above each bar is the total amount of emissions for the source. The sources are in order of increasing total amount of emissions.

City Facilities

City facilities include airports, athletic courts, community centers, office buildings, warehouses, water treatment plants, and other facilities owned or operated by the City of Concord government. These are stationary buildings or structures that use energy. We also included crosswalk signals, streetlights, and traffic signals in facilities. Stationary fuels and electricity are used in City facilities.

Stationary fuel. Natural gas was the only fuel used in City facilities. City facilities consumed about 59,700 thousand cubic feet (mcf) of natural gas in 2019, releasing 3,265 MT CO_2e in GHGs (**Table 4.1**). Estimating the total cost of this fuel source from the US EIA, the City spent more than $157,813 on natural gas in 2019. However, this estimate may significantly underestimate the total cost. Emissions from natural gas was the largest source of GHGs in the LGO inventory. This fuel contributed 27% to the total amount of LGO inventory emissions (3,265 out of 11,564 MT CO_2e).

Table 4.1: Summary of 2019 natural gas consumption

	2019 Natural Gas
Consumption (mcf)	59,734
Energy Use (MMBtu)	61,406
Emissions (MT CO_2e)	3,265
Total Energy Cost ($)	157,813

mcf is thousand cubic feet. MMBtu is million British thermal unit. MT CO_2e is metric tons of carbon dioxide equivalent. The US EIA 2019 average natural gas spot price of $2.57 per MMBtu was used to calculate energy cost[42].

As expected, City facilities consumed the most natural gas in the winter months (**Figure 4.2**). This fuel is also referred to as a heating fuel for buildings. City facilities consumed the most natural gas in February 2019 (663 out of 3,265 MT CO_2e), followed by January (603 out of 3,265 MT CO_2e).

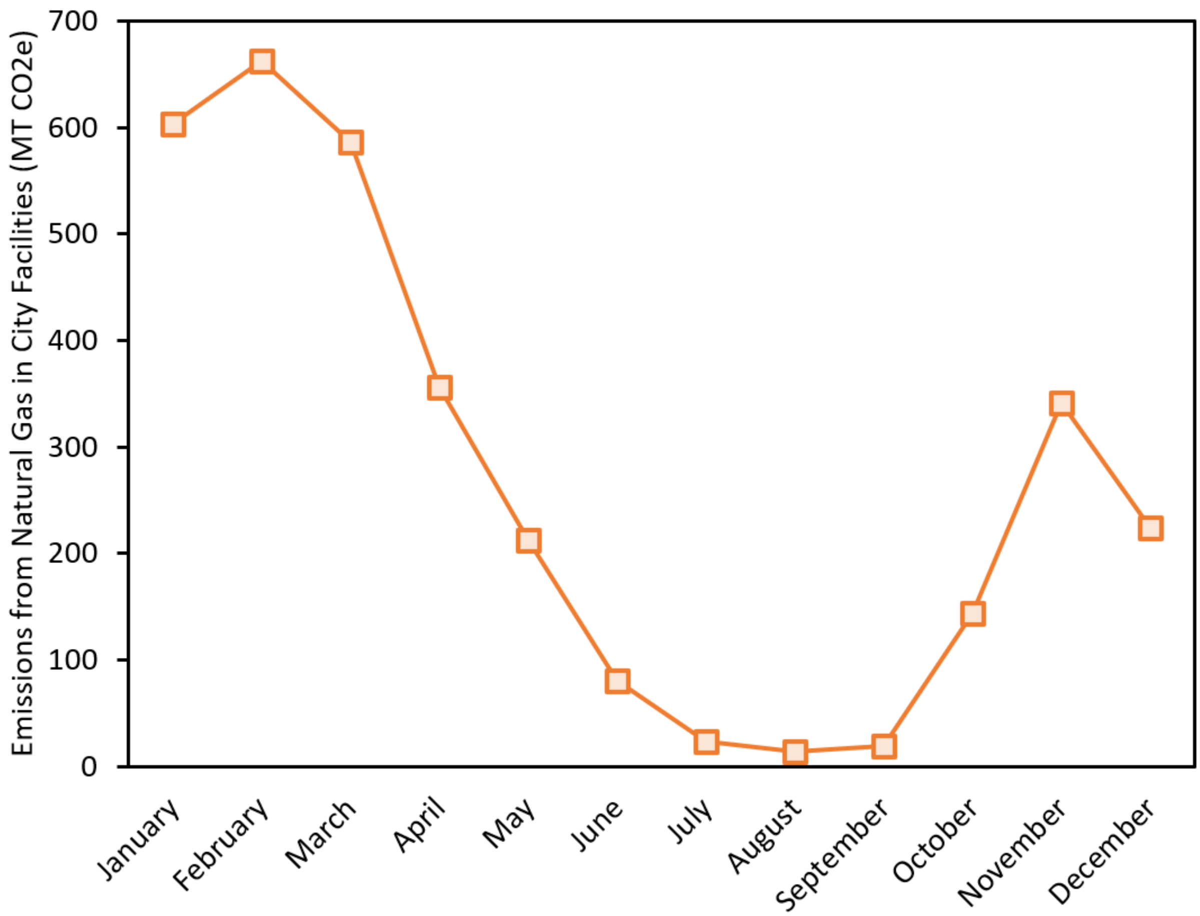

Figure 4.2: Estimated greenhouse gas emissions (MT CO_2e) released by City facilities for natural gas consumption each month of 2019.

Exploring the provided billing records for natural gas, we analyzed a subset of eighteen City facilities. These 18 facilities collectively released 805 MT CO_2e, costing the City $118,732.05 in fuel bills (**Table 4.2**). Typically, you would see a trend of increasing fuel consumption and increasing fuel cost when comparing the values. However, we noticed not all eighteen buildings follow this trend (**Figure 4.3**). The Combined Operations Maintenance Facility (COMF) and the City Hall Annex Building (labelled City Hall in **Figure 4.3**) collectively emitted 50 MT CO_2e, but they cost $39,651 to use. The City-Wide Community Center also emitted lower GHGs, but the facility had the fourth highest cost. It is possible there is a problem to explore further. For reference, the facility that emitted the most GHGs was the Hall Street Wastewater Treatment Plant (WWTP) at 300 MT CO_2e, costing $25,101 to use (**Figure 4.4**). The second highest emitter was the Douglas N Everett Ice Arena (114 MT CO_2e); however, there is a difference of 186 MT CO_2e between the Hall Street WWTP and the Ice Arena.

Table 4.2: Summary of natural gas consumption in 18 City facilities

City Facility	Consumption	Billed Amount	Emissions	Energy Use
-	mcf	$	MT CO_2e	MMBtu
Beaver Meadow Golf Course	655	4073.62	36	673
City Hall Annex Building	453	19806.59	25	466
City Wide Community Center	795	11524.16	43	817
COMF (Combined Operations Maintenance Facility)	461	19844.17	25	474
Communications Center (Fire)	109	1095.85	6.0	112
Concord Calvary Cemetery	121	1876.04	6.6	125
Concord Fire Headquarters	291	1854.15	16	299
Concord Fire Prevention Bureau	270	1642.85	15	278
Douglas N Everett Ice Arena	2084	10359.62	114	2142
East Concord Community Center	0.10	559.76	0.01	0.10
Hall Street Wastewater Treatment Plant & Watershed	5490	25100.83	300	5644
Penacook Wastewater Treatment Plant	637	3264.06	35	655
Fire Station 1 - Central	755	3748.00	41	776
Fire Station 4 - Broadway	406	2341.10	22	417
Fire Station 5 - Manor	779	3819.79	43	801
Fire Station 7 - Heights	440	2524.01	24	452
Water Treatment Plant & Pump	860	4141.97	47	884
West Street Ward House	129	1155.48	7	133
Total	**14,735**	**118,732.05**	**805**	**15,148**

This sample of 18 facilities was aggregated from monthly billing records provided by the City Finance department. We matched facilities to service addresses to the best of our ability.

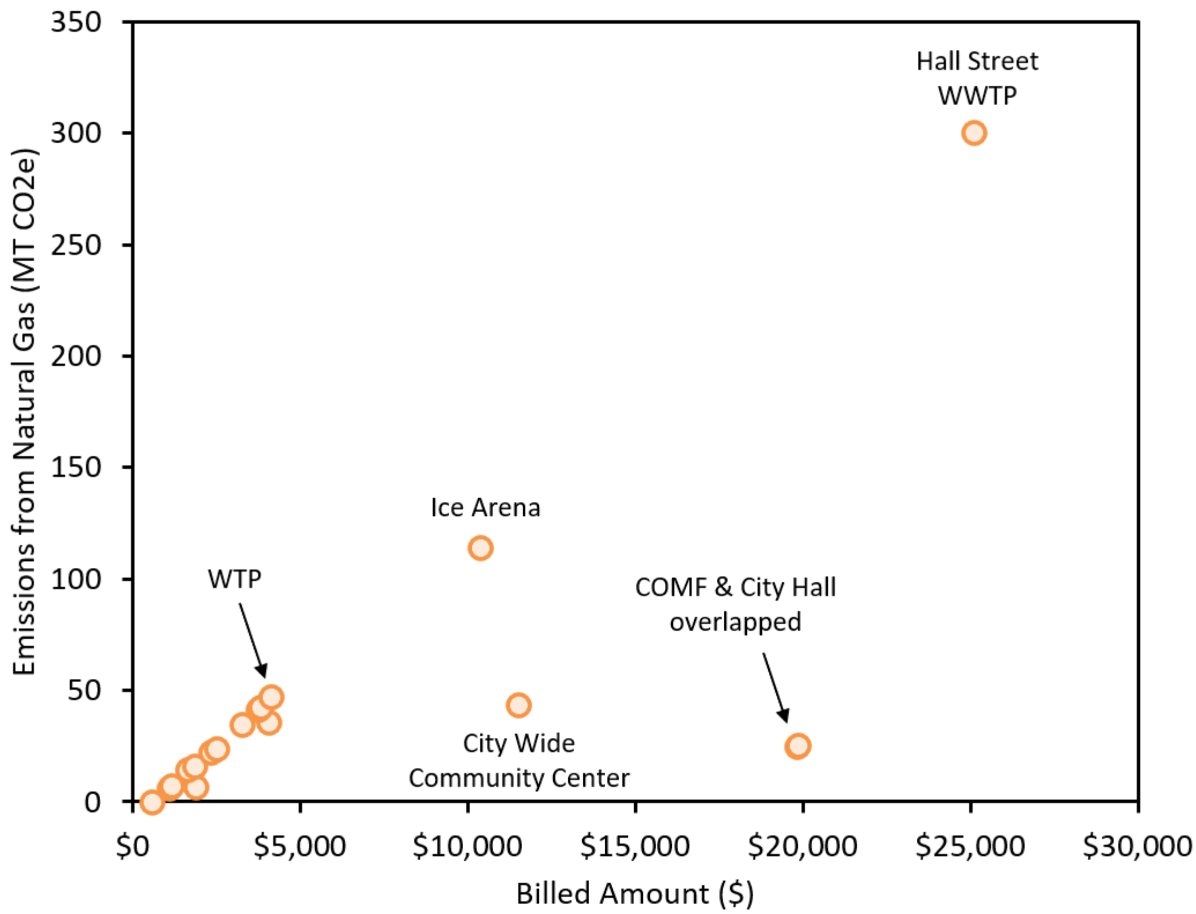

Figure 4.3: Estimated greenhouse gas emissions (MT CO_2e) emitted by a sample of 18 City of Concord government facilities for natural gas consumption as a function of the billed amount ($) in 2019. The top six most costly facilities are labelled. WTP is water treatment plant. WWTP is wastewater treatment plant. COMF is Combined Operations Maintenance Facility.

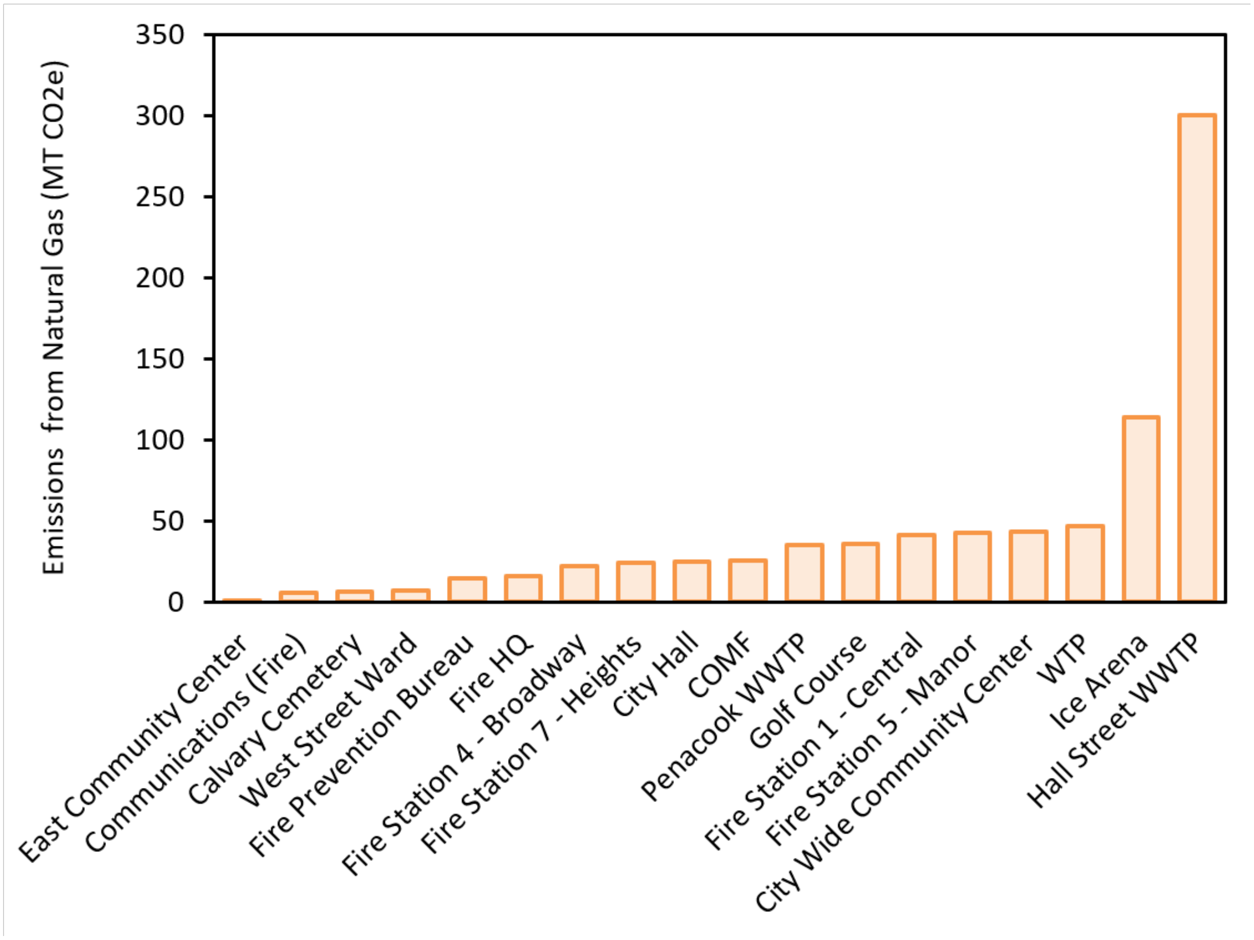

Figure 4.4: Estimated greenhouse gas emissions (MT CO_2e) emitted by a sample of 18 City of Concord government facilities for natural gas combustion in 2019. Facilities are ordered by lowest to greatest emissions. WTP is water treatment plant. WWTP is wastewater treatment plant. COMF is Combined Operations Maintenance Facility. HQ is headquarters.

Electricity use. All local governments are likely to have indirect emissions associated with the purchase and use of electricity. City facilities used about 10.5 million kilowatt-hours (kWh) of electricity in 2019, releasing 2,507 MT CO_2e in GHGs (**Table 4.3**). As the third largest source of GHGs, electricity use accounted for 21% of the total amount of LGO inventory emissions. Fortunately, the City fully offsets this usage with renewable energy credits (RECs). Estimating the total cost of this fuel source from the US EIA, the City spent about $1,780,474 on electricity use in 2019.

Table 4.3: Summary of 2019 electricity use

	2019 Electricity
Usage (kWh)	10,473,376
Energy Use (MMBtu)	35,745
Emissions (MT CO_2e)	2,507
Total Energy Cost ($)	1,780,473.92

kWh is kilowatt-hour. MMBtu is million British thermal unit. MT CO_2e is metric tons of carbon dioxide equivalent. The average May 2019 price of electricity to NH customers of $0.17 per kWh was used to calculate energy cost[43].

With the data received from Unitil, we analyzed a sample of City facilities to understand which ones emitted the most GHGs with respect to electricity use. Nineteen facilities had complete data to analyze. Fifteen out of nineteen facilities with complete data were chosen because they had higher GHG emissions (**Table 4.4**). These facilities collectively emitted about 1,688 MT CO_2e from 7.1 million kWh of electricity. The Hall Street Wastewater Treatment Plant (WWTP) released the most GHG emissions in 2019 (684 MT CO_2e) [**Figure 4.5**]. The Water Treatment Plant (WTP) released the second most GHG emissions (260 MT CO_2e); however, there is a difference of 424 MT CO_2e between the facilities.

Table 4.4: Summary of electricity use in 15 highest emitting City facilities and infrastructure

City Facility	Consumption	Energy Use	Emissions
-	kWh	MMBtu	MT CO_2e
Beaver Meadow Golf Course	28435	97	7
COMF (Combined Operations Maintenance Facility)	369400	1261	88
Communications Center	189680	647	45
Concord Public Library - Main Library	216720	740	52
Crosswalk & Traffic Signals	97098	331	23
Douglas N Everett Ice Arena	342970	1171	82
Hall Street Wastewater Treatment Plant	2857950	9754	684
Penacook Wastewater Treatment Plant	681280	2325	163
Police Station	794000	2710	190
Station 1 - Central Fire House	112341	383	27
Station 4 - Broadway Fire Station	51240	175	12
Station 5 - Manor Fire Station	82360	281	20
Station 7 - Heights Fire Station	66344	226	16
Streetlights*	53818	184	13
Water Treatment Plant	1085435	3705	260
Total	**7,054,403**	**24,076**	**1,688**

[a]City streetlights include downtown, ornamental, outdoor, park, and replacement lights. kWh is kilowatt-hour. MMBtu is million British thermal units.

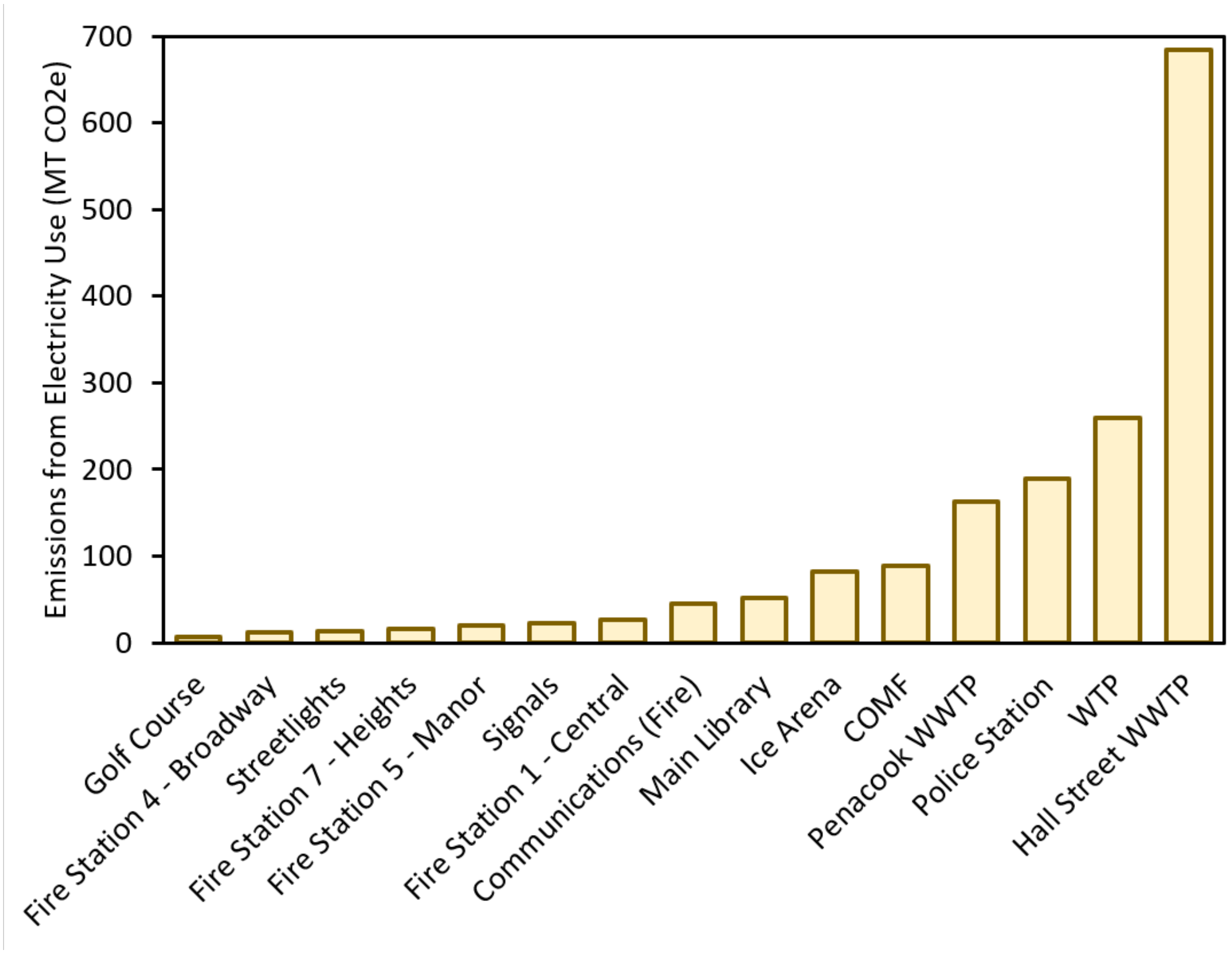

Figure 4.5: Estimated greenhouse gas emissions (MT CO_2e) emitted by a sample of 15 City of Concord government facilities for electricity use in 2019. Facilities are ordered by lowest to greatest emissions. Only the top 15 facilities are shown on the graph. COMF is Combined Operations Maintenance Facility. Lights include downtown, ornamental, outdoor, park, and replacement lights. Signals include crosswalk and traffic signals. WTP is water treatment plant. WWTP is wastewater treatment plant.

Energy use in City facilities. To compare stationary fuel combustion and electricity usage, we converted both sources to million British thermal units (MMBtu). MMBtu is the standard unit used to assess how much energy different fuels use. For reference, one MMBtu is equal to the energy released by burning one million matches. Generally, City facilities combusted natural gas (total of 61,406 MMBtu) more than they used electricity (total of 35,745 MMBtu). However, we wanted to look a little closer. Which City facilities use natural gas more than electricity?

We compared energy use between 14 facilities that had both data available (**Figure 4.2**). Six out of the fourteen facilities used more energy as electricity than as natural gas. However, the Ice Arena (3,312 MMBtu) and seven other facilities consumed more natural gas than electricity. Overall, the Hall Street WWTP consumed the most energy out of the facilities (15,398 MMBtu), followed by the WTP (4,589 MMBtu).

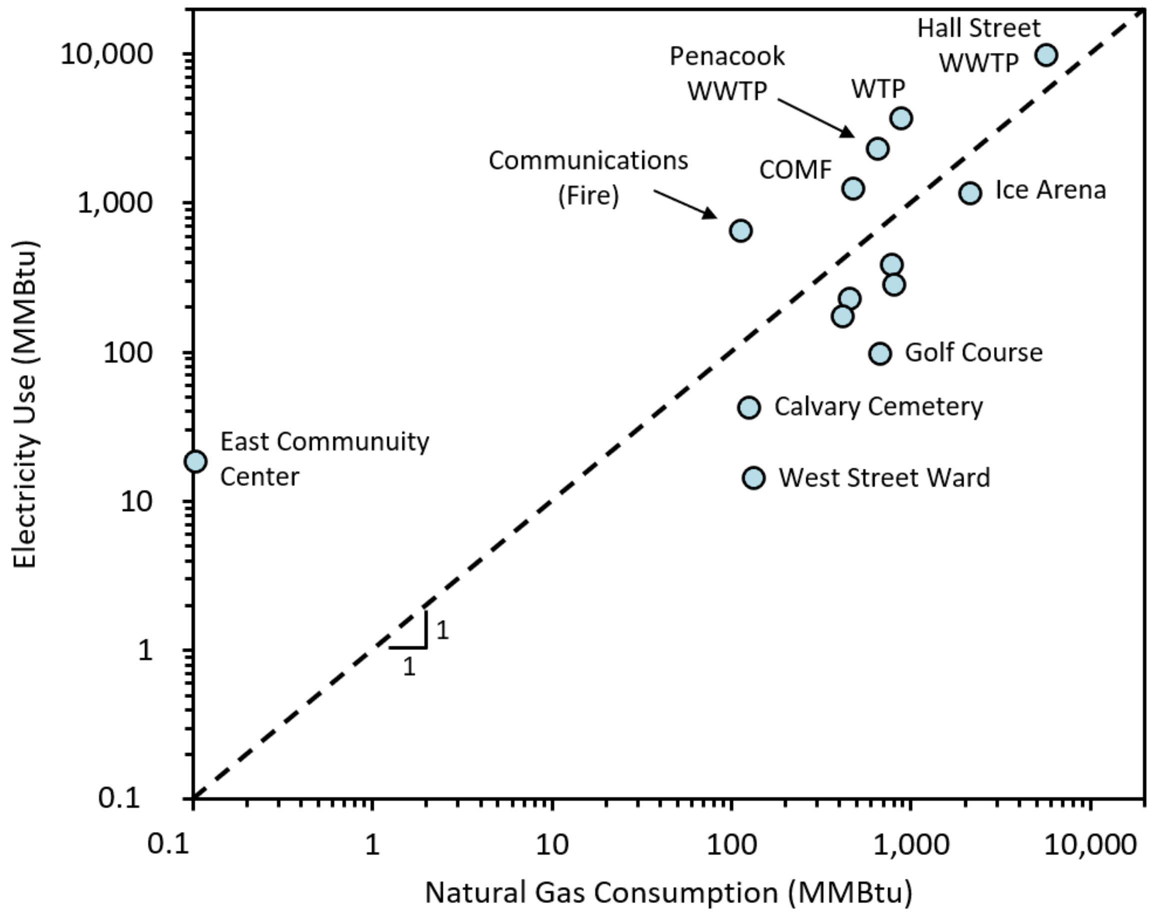

Figure 4.6: Energy use of electricity (MMBtu) as a function of the energy use of natural gas (MMBtu) emitted by a sample of 14 City of Concord government facilities in 2019. Both axes are on a logarithmic scale. The black dashed line is the one-to-one line, where facilities above the line use more electricity and facilities below the line use more natural gas. Only 14 facilities had data for both electricity use and natural gas consumption. COMF is Combined Operations Maintenance Facility. WTP is water treatment plant. WWTP is wastewater treatment plant.

Employee Commute and Business Travel

Employee commute. The emissions associated with travel of employees to and from work in personal vehicles are classified as Scope 3 emissions. Local governments can often influence these emissions through various programs (*i.e.*, carpools and flex schedule options) despite not having direct control over them.

We found that 1,384 MT CO_2e were released in 2019 due to City staff commuting to work. General Services released the most emissions (314 MT CO_2e), followed by the Police (297 MT CO_2e) and the Fire Department (248 MT CO_2e) [**Table 4.5; Figure 4.7**]. Although these divisions accounted for most of the GHGs, they also have the most active staff members. The emissions per City employee were estimated at 2.4 MT CO_2e per employee. Employee commute contributed to 11% of the total amount of LGO inventory emissions.

The average one-way commuting distance was 13 miles, where the median distance was 10 miles. Since the median distance is smaller than the average, there are quite a few participants who commuted much closer than the majority and, therefore, skew the average. The longest commuting distance was 52 miles, and the shortest was near 0 miles. The average amount of days participants worked in 2019 was 212 days, where the median was 240 days. Like the commuting distance, there are participants who are skewing the average. The longest work year a participant had was 359 out of 365 days in 2019.

Table 4.5: Greenhouse gas emissions released from employee commuting

Consolidated Division[a]	**Single Occupancy Vehicle**	**Motorcycle**	**Total Emissions**
-	MT CO_2e	MT CO_2e	MT CO_2e
Assessing	22	0.2	22
City Clerk	9.7	0.1	9.7
Community Development	99	0.7	100
Finance and Purchasing	46	0.3	46
Fire Department	246	1.7	248
General Services (Public Works)	311	2.2	314
Human Resources	9.7	0.1	9.7
Human Services	9.7	0.1	9.7
Information Technology	17	0.1	17
Legal	24	0.2	24
Library	72	0.5	73
Parks and Recreation	212	1.5	214
Police	295	2.1	297
Total	**1,374**	**9.6**	**1,384**

Only single occupancy vehicles and motorcycles have emissions associated with them. No participants chose carpooling as an option. Transit is already considered in Vehicle Fleets. [a]The departments included in the survey do not completely match the divisions provided by Human Resources. To address this discrepancy, some departments were consolidated into one division.

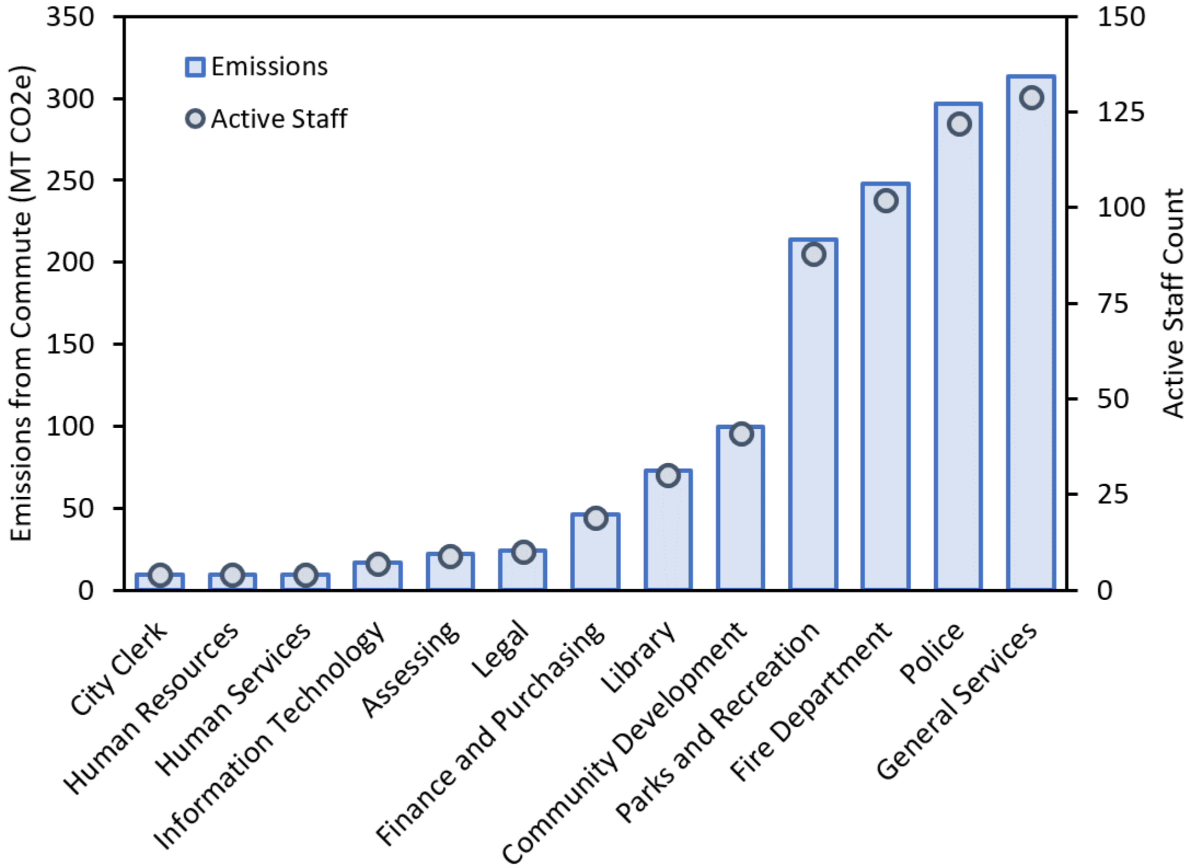

Figure 4.7: Estimated greenhouse gas emissions (MT CO_2e) released from each City of Concord government division for employee commute in 2019. The grey-blue circle is the total number of active staff in each division. General Services includes Public Works.

Employee business travel. The emissions associated with employees travelling on behalf of the local government are also classified as Scope 3 emissions. We found that 38 MT CO_2e were released in 2019 due to City staff travelling for work-related events. Community Development emitted the most emissions (15 MT CO_2e), followed by General Serves (11 MT CO_2e) and Parks and Recreation (4.4 MT CO_2e) [**Figure 4.8**]. Business travel in 2019 summed to $54,214 to cover the cost of City staff driving over 93,000 miles (**Table 4.6**). Virtually all business travel was by car.

Table 4.6: Greenhouse gas emissions released from employee business travel

Consolidated Division[a]	Travelled Mileage	Vehicle Miles[b]	Fuel Consumed[c]	Total Emissions
-	$	Miles	Gallons	MT CO_2e
Assessing	3156.64	5442	252	2.2
City Clerk	0.00	0	0	0
Community Development	21508.77	37084	1717	15
Finance and Purchasing	1244.46	2146	99	0.9
Fire Department	0.00	0	0	0
General Services (Public Works)	16322.19	28142	1303	11
Human Resources	500.03	862	40	0.4
Human Services	172.26	297	14	0.1
Information Technology	348.84	601	28	0.2
Legal	2781.09	4795	222	1.9
Library	1934.56	3335	154	1.4
Parks and Recreation	6245.23	10768	499	4.4
Police	0.00	0	0	0
Total	**54,214.07**	**93,473**	**4,327**	**38**

Business travel is assumed to be all car travel. [a]The departments included in the survey do not completely match the divisions provided by Human Resources. To address this discrepancy, some departments were consolidated into one division. [b]Vehicle miles travelled were estimated from the travelled mileage at $0.58 per mile. [c]Fuel consumption was estimated at 21.6 miles per gallon.

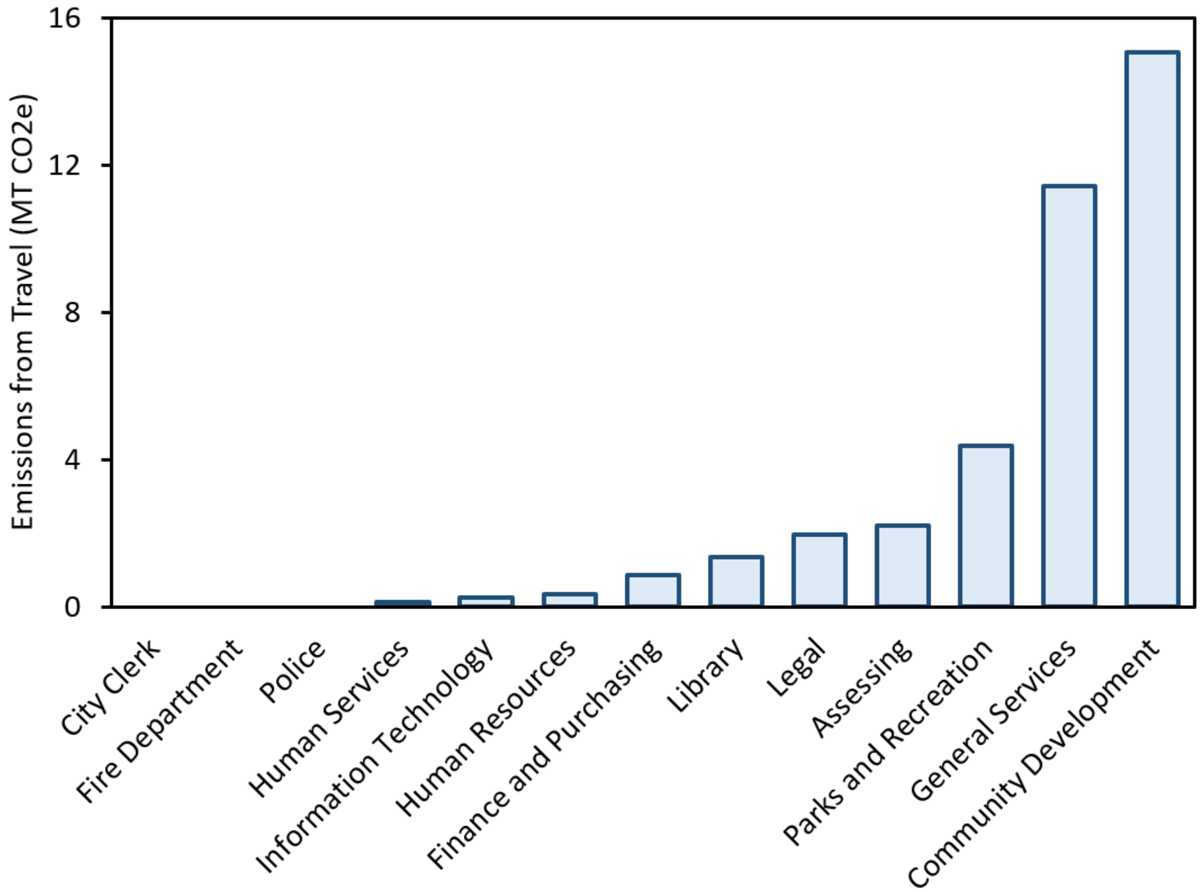

Figure 4.8: Estimated greenhouse gas emissions (MT CO_2e) released from each City of Concord government division for employee business travel in 2019. General Services includes Public Works. Divisions are ordered by lowest to greatest emissions.

Fertilizer Use

The City applies synthetic fertilizer to the grounds of the Beaver Meadow Golf Course and the athletic fields in City parks. During 2019, Parks and Recreation only applied fertilizer in the fall season instead of the spring and fall seasons as they normally operate. There was a total of 1.4 short tons of nitrogen in the fertilizer. The City emitted about 11 MT CO_2e of GHGs. This is the smallest contribution to the total amount of GHGs emitted in the LGO inventory.

Solid Waste Generation

In 2019, 206 MT CO_2e of GHGs were released from waste generated in City facilities. Under the Solid Waste Flow Control Ordinance (Ord. No. 2960, § I, 6-13-16), Concord sends their municipal solid waste to a Casella Waste Systems landfill in Bethlehem, NH (NCES landfill). In addition to landfilled waste, Concord sends their recyclables to a recycling center in Charlestown, NH. Leaf and yard waste are processed in Concord at a City-owned site for composting.

Vehicle Fleets

A local government's vehicle fleet may contain a wide array of vehicles running on a variety of fuels. In Concord, 222 vehicles were used by the City in 2019, where 48 of them were construction, recreation, or utility equipment. Five out of thirteen consolidated divisions (see **Table 3.1** for reference) used City vehicles: (1) Community Development, (2) Fire Department, (3) General Services, (4) Parks and Recreation, and (5) Police.

In 2019, the City released 1,546 MT CO_2e from vehicle and equipment usage, amounting to 13% of the total amount of LGO inventory emissions. General Services released the most emissions (741 MT CO_2e), followed by the Police (364 MT CO_2e) and the Fire Department (315 MT CO_2e) [**Table 4.7**]. Exploring the average emissions, about 7.0 MT CO_2e was emitted per City vehicle. The total fuel cost for vehicles and equipment was $326,910.

Table 4.7: Summary of vehicle and equipment use in City divisions

Consolidated Division	**Vehicles Used**	**Fuel Cost**	**Energy Use**	**Emissions**
-	Count	$	MMBtu	MT CO_2e
Community Development	7	5857.25	382	27
Fire Department	32	65581.45	4302	315
General Service (Public Works)	122	154838.95	10186	741
Parks and Recreation	21	21155.46	1382	98
Police	40	79476.81	5180	364
Total	**222**	**326,909.92**	**21,431**	**1,546**

Vehicle miles travelled are not included in this table because not all vehicles and equipment travelled on a road. Fuel consumption is not included in this table due to the different types of fuel each division's vehicles used.

Wastewater Treatment

As the second largest source of GHGs, wastewater treatment contributed 26% to the total amount of LGO inventory emissions. Local governments are usually responsible for providing wastewater services to their communities, such as wastewater collection, primary and secondary treatment, solids handling, and effluent discharge. The City owns two WWTPs: (1) the Hall Street WWTP, and (2) the Penacook WWTP (**Table 3.3**). The Hall Street and Penacook WWTPs emitted a total of 3,093 MT CO_2e in GHGs in 2019. About 89% of these emissions were methane, whereas the other 11% was from nitrous oxide. Surprisingly, most of the emissions were from individual domestic septic tanks processed at the Hall Street WWTP (2,753 out of 3,093 MT CO_2e). The Hall Street WWTP processes about two million gallons of domestic septage from local communities annually[34].

Reducing GHG Emissions

The City government has taken several steps to reduce its climate footprint and energy usage, such as:

- Embracing the NH Climate Action Plan to reduce GHG emissions 80% by 2050;
- Investing in energy efficiency projects and purchasing green energy for City buildings; and

- Signing the Climate Mayors Agreement to uphold the Paris Climate Accord and develop a climate action plan[3]. The Paris Climate Accord requires signatories to collectively reach GHG emissions reductions targets necessary to keep warming < 1.5°C, thereby avoiding the worst effects of climate change.

In July 2018, the City of Concord adopted a 100% renewable energy goal by unanimous vote of the City Council[3]. The City committed to the following community-wide goals:

1. 100% of electricity consumed in Concord will come from renewable energy sources by 2030;
2. 100% of thermal energy (heating and cooling) consumed in Concord will come from renewable energy sources by 2050; and
3. 100% of transportation in Concord will be clean transportation by 2050[3].

The emissions reduction recommendations provided in this section consider the NH Climate Action Plan recommendation of 80% by 2050 and the City's 100% renewable energy goal.

Recommended Strategies

Audit City facilities for refrigerants and other fugitive emissions. Although refrigerants and other fugitive emissions were not included in this inventory, they may contribute a significant amount of greenhouse gas emissions. Specifically, for the Ice Rink, the City should record the amount of different coolants City refrigeration systems use. Coolants using hydrofluorocarbons (HFCs) and other fluorinated gases have high Global Warming Potentials and will emit more GHGs than carbon dioxide. With initiatives to shift away from HFC coolants, more skating rinks are using systems optimized for primary coolants like ammonia (R-717) and carbon dioxide (R-714)[44]. For example, an ice rink in Sweden installed a 100% carbon dioxide system combined with an optimized heat pump to reduce its energy consumption by 50% to 60%[44].

Convert electricity sources to solar and wind. In 2019, the City of Concord government purchased an estimate of 10,473 megawatt-hours (MWh) of electricity in the form of renewable energy certificates (RECs). These RECs cost a unit price of $0.90 per MWh or a total of $9,426 for the year. The RECs offset 100% of the emissions released by Electricity Use (2,507 out of 2,507 MT CO_2e), or 21% of the total amount of LGO inventory emissions (2,507 out of 12,049 MT CO_2e).

If the City were to invest in a solar field to produce electricity locally, the field would need to produce about a thousand megawatt-hours annually to offset the City's electricity use by twelve percent (**Table 4.8**). The City should also consider investing in new sources of electricity in the surrounding local area as much as possible.

Table 4.8: Reductions in emissions with locally produced electricity

Electricity Production[a]	Emissions Saved	Electricity Use Reduction[b]	LGO Emissions Reduction[c]
MWh	MT CO_2e	%	%
10	2	-0.1	-0.02
100	24	-1.0	-0.2
500	120	-4.8	-1.0
1,000	239	-10	-2.0
5,000	1197	-48	-10
7,500	1795	-72	-15

10,000	2393	-95	-20

MWh is megawatt-hour. The 2019 eGRID emissions factors were used here. [a]Electricity Produced is the total electricity produced in one year. [b]Electricity Use Reduction is the percent change in Electricity Use emissions with the amount of electricity produced by the solar field. [c]LGO Emissions Reduction is the percent change in LGO inventory emissions with the amount of electricity produced by the solar field.

Electrify City fleets and build electric charging infrastructure. The City should reduce idling in vehicle fleets. Idling is running your engine when you are not driving it. Idling reduces a vehicle's fuel economy, costs money, and creates pollution. According to the US Department of Energy (DOE), idling for more than 10 seconds uses more fuel and produced more emissions that contribute to smog and climate change than stopping and restarting your engine[45]. Researchers estimate that idling from heavy-duty and light-duty vehicles combined wastes about six billion gallons of fuel in the US each year[45].

Another option to reducing emissions released by City vehicle fleets is to switch gasoline- and diesel-powered cars and light trucks to electric vehicles. Light trucks include pickup trucks, SUVs, and vans. If the City switched all passenger cars used in 2019 (25 out of 222 vehicles) to electric vehicles, vehicle fleet emissions could be reduced by 9% (144 out of 1,546 MT CO_2e). If the City switched all light trucks used in 2019 (108 out of 222 vehicles) to electric vehicles, vehicle fleet emissions could be reduced by 48% (743 out of 1,546 MT CO_2e).

Encourage efficiency in employee commuting. In the employee commute survey administered in the City, we asked participating City staff which alternative mode of transportation they would use if they usually drive alone (*i.e.*, in a car, in a truck, or on a motorcycle). The available choices were carpool, vanpool, transit, bike, or walk, and participants could check all that applied. 145 out of 155 participating City staff used a single occupancy vehicle or motorcycle. These participants made 166 choices for an alternative mode of transportation (**Table 4.9**).

Table 4.9: Summary of alternative transportation choices

Mode	Total Choices	Percent Chosen
-	Count	%
Bike	51	31
Carpool	82	49
Transit	13	8
Vanpool	7	4
Walk	13	8
Total	**166**	**100**

145 out of 155 participants use a single occupancy vehicle or motorcycle; however, only 143 out of the 145 participants answered this question.

More than half of the participants would consider a carpooling or vanpooling program (54%; 89 out of 166 choices). In addition, a little over a third of the participants would consider biking or walking to work (39%; 64 out of 166 choices). If these modes of transportation were utilized, employee commute emissions could reduce significantly (**Table 4.10**). The reduction strategies explored are:

1. 54% of employees (307 out of 569 active staff) switched to a carpooling or vanpooling program, according to the survey choices.
2. 39% of employees (222 out of 569 active staff) switched to biking or walking, according to the survey choices.
3. If both strategies occurred.

If both strategies occurred, employee commute emissions could reduce up to 66% (476 out of 1,384 MT CO_2e). These strategies could reduce the total amount of LGO inventory emissions by 7.5% (11,142 instead of 12,049 MT CO_2e).

Table 4.10: Reduction recommendations for employee commuting

Strategy	Emissions	Employee Commute Reduction
-	MT CO_2e	%
54% Carpool + Vanpool	973	-30
39% Bike + Walk	898	-35
Both Strategies	**476**	**-66**

We assumed a vanpool program of six people per van and a carpool program of two people per van. We assumed people would bike, walk, carpool, and vanpool to and from work. We calculated commute reductions with percent change from the 2019 Employee Commute emissions of 1,384 MT CO_2e.

Invest in City-owned forests. Carbon sequestration secures carbon dioxide (CO_2) to prevent it from entering the Earth's atmosphere. This carbon sink is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change.

Since urban forestry was not included at the local government operations scale, the City should first survey and account for the forests they own and the urban tree cover on City land. Forests at these scales would help reduce GHG emissions significantly (**Table 4.11**).

Table 4.11: Emissions removed by carbon sequestration

Forest Size	Emissions Removed	LGO Emissions Reduction
Acres	MT CO_2e	%
100	331	-2.7
250	827	-6.9
500	1655	-14
1,000	3309	-27
2,500	8273	-69
5,000	16545	-137

We assumed 100% tree cover in forests. We used the carbon sequestration factor from EPA LGGIT.

Reduce energy use in City facilities, prioritizing the highest users. The City should focus on reducing energy use (*i.e.*, electricity use and natural gas combustion) at the Hall Street and Penacook

Wastewater Treatment Plants (WWTPs), the Water Treatment Plant (WTP), the Douglas N Everett Ice Arena, and the COMF the most since these facilities used the most energy in 2019 (**Table 4.12**). Collectively, those five facilities contributed 15% to the total amount of LGO inventory emissions. A few energy efficiency strategies could be:

- Install programmable thermostats: a programmable thermostat can adjust the facility to a set temperature during business hours and a different temperature outside of business hours;
- Consider heat recovery: any piece of equipment that produces heat can use a heat exchanger to help offset the heating need from heating, ventilation, and air conditioning (HVAC) equipment;
- Install motion sensitive light switches;
- Use high-efficiency light-emitting diode (LED) lighting; and
- Weatherize buildings and facilities: air sealing and insulating measures.

Table 4.12: Summary of the five City facilities that used the most energy in 2019

City Facility	**Energy Use**	**Emissions**
-	MMBtu	MT CO_2e
Hall Street Wastewater Treatment Plant	15398	984
Water Treatment Plant	4589	307
Douglas N Everett Ice Arena	3312	196
Penacook Wastewater Treatment Plant	2980	198
Combined Operations Maintenance Facility	1735	114
Total	**28,014**	**1,798**

Ordered from largest to smallest energy users. Energy use and emissions are for natural gas and electricity only.

Next Steps

This inventory establishes the baseline GHG emissions for local government operations. Moving forward, the City should take steps to reduce emissions focused on stationary fuel, electricity use, and transportation (*i.e.*, employee commuting and City vehicle fleets). These sources collectively contributed to 72% of the LGO inventory emissions (8,701 out of 12,049 MT CO_2e). The City should also consider fugitive emissions in facilities and fleets. A few years later, an updated GHG inventory should be conducted to benchmark any progress.

Local Government Operations Inventory Summary Table

Table 4.13: Summary of 2019 local government operations inventory emissions

Source	LGO Emissions
-	MT CO_2e
Electricity Use	2507
Employee Commute	1384
Employee Travel	38
Fertilizer Use	11
Solid Waste Generation	206
Stationary Fuel (*Natural Gas*)	3265
City Vehicle Fleet – CNG	*1*
City Vehicle Fleet – Diesel	*810*
City Vehicle Fleet – Gasoline	*735*
All Transportation	1546
Wastewater Treatment	3093
Total Emissions	**12,049**

CNG is compressed natural gas. LGO is local government operations.

5. Community-Wide Inventory

Results

Overview

In 2019, we estimated that the Concord community released 495,905 metric tons of carbon dioxide equivalent (MT CO_2e) in gross GHG emissions. In this inventory, we explored emissions and removals from ten different sources (**Figure 3.2**) and three different sectors (*i.e.*, commercial + institutional, local government, and residential areas). Including the removal of carbon by urban forestry, the net GHG emissions from the community was 483,443 MT CO_2e in 2019.

Stationary fuel caused over one-third of the gross emissions released by the community (35%; 175,551 out of 495,905 MT CO_2e). Transportation (28%), electricity use (18%), and industrial processes (15%) were also major emissions sources (**Figure 5.1A**). Transmission and distribution (T&D) losses, wastewater treatment, farm animals, and fertilizer use collectively contributed under two percent of the gross emissions (1.9%; 9,379 out of 495,905 MT CO_2e).

The commercial and institutional sector accounted for half of the gross GHG emissions in Concord (50%; 245,802 out of 495,905 MT CO_2e), where stationary fuel contributed the most emissions within the sector [**Figure 5.1B**]. The residential sector accounted for 48% of the gross emissions (239,353 out of 495,905 MT CO_2e), where transportation contributed the most emissions within the sector. Exploring average residential emissions further, *about 5.6 MT CO_2e was emitted per Concord resident in 2019*.

Surprisingly, only two percent of the gross emissions were from local government (10,750 out of 495,905 MT CO_2e). In this inventory, the local government sector was estimated using a different protocol than in the **Local Government Operations Inventory**, so it excluded a couple of those emission sources.

While climate action planning, the City should focus on natural gas and other heating fuels combustion from stationary fuels, passenger cars and light trucks from transportation, and electricity consumption. It is not clear what commercial businesses emit the most GHGs from this study; however, *identifying and working with the largest entities in Concord may significantly reduce community-wide emissions*.

The setup. The following sections are in alphabetical order:

1. The Built Environment (including stationary fuels, electricity use, industrial processes, and transmission and distribution losses)
2. Farm Animals and Fertilizer Use
3. Solid Waste Generation
4. Transportation
5. Urban Forestry

Although emissions from wastewater treatment are included in this inventory, please refer to the **LGO Inventory** for more information. When differentiating between the local government and community, “City” will be used for the Concord government, and “city” will be used for the Concord community. A sector is a segment of the community in which data was aggregated. In this inventory, three main sectors are used:

1. Commercial + Institutional—commercial businesses, industrial facilities, and institutions other than the local government (*i.e*., state government and public schools);
2. Local government—the buildings and facilities operated or owned by the City government; and
3. Residential—areas where residents live.

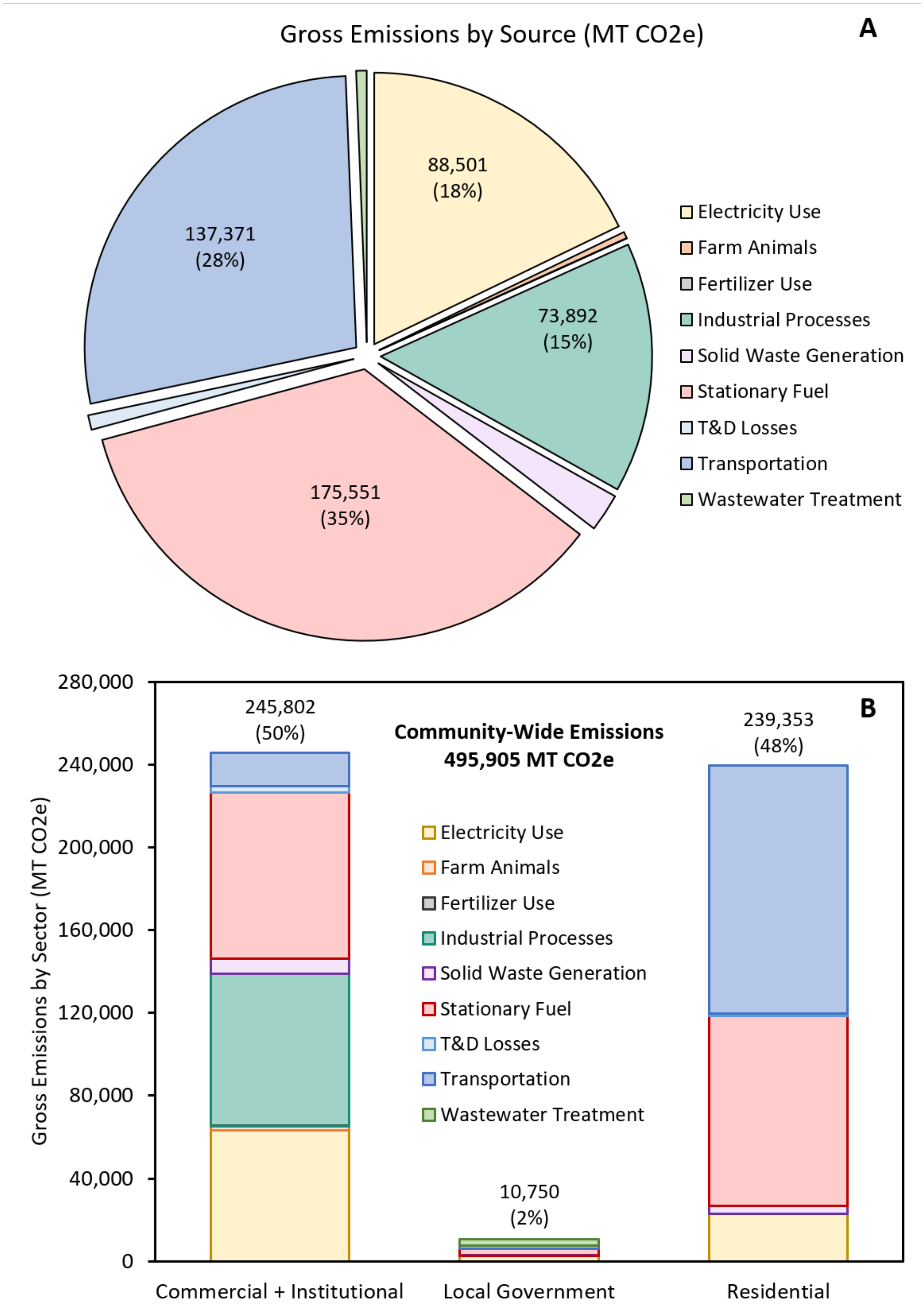

Figure 5.1: Estimated gross greenhouse gas emissions (MT CO_2e) emitted by each community source (**A)** and sector (**B**) in 2019. In **Figure 5.1A**, the total amount of gross emissions and the percent of emissions for the four biggest emission sources are labelled in the pie chart. In **Figure 5.1B**, the total amount of gross emissions is labelled at the top of each bar and the percent of gross emissions is in parentheses for each sector (*i.e.*, commercial + industrial, municipal, residential). T&D is transmission and distribution. A similar figure is in the **Executive Summary** with proportional symbols.

The Built Environment

As defined by the US Community Protocol (USCP), the built environment includes the human-made surroundings that provide the living and working spaces for human activity, ranging in scale from personal shelter and buildings to neighborhoods and cities that include supporting infrastructure, such as energy networks[28]. GHG emissions attributed to the built environment include those from municipal, residential, commercial, and industrial buildings; the operational processes and human activities with those buildings; and electric vehicle use[28]. These emissions are limited to energy used within buildings, refrigerants, fire suppressants, and industrial processes[28].

Released emissions and consumed energy. The total amount of GHG emissions associated with the built environment in 2019 was 337,944 MT CO_2e. This total amount includes electricity use, stationary fuels combusted in the three sectors, and stationary fuels combusted through industrial processes. Related to electricity use, a total amount of 4,321 MT CO_2e was released due to transmission and distribution (T&D) losses in Concord power lines. Including T&D losses, the total amount GHG emissions associated with the built environment was 342,264 MT CO_2e in 2019. In the following information, we will focus on electricity use and stationary fuels (337,944 MT CO_2e of emissions from **Table 5.1**).

Table 5.1: Emissions from electricity, industrial processes, and stationary fuels in the community

Source	Commercial & Institutional	Municipal	Residential	Total Emissions per Source
-	MT CO_2e	MT CO_2e	MT CO_2e	MT CO_2e
Electricity	63137	2507	22857	**88,501**
Fuel Oil[b]	8845	*NU*[d]	28321	**37,165**
Natural Gas	71607	3265	41758	**116,630**
Propane	83[f]	*NU*	7020	**7,104**
Propane + MSW[a]	73892	*NU*	*NU*	**73,892**
Wood	*ND*[c]	*NU*	14652	**14,652**
Total Emissions per Sector	**217,563**[e]	**5,772**[e]	**114,609**[e]	**337,944**[e]

[a]This source includes the aggregated propane and municipal solid waste (MSW) emissions by the Wheelabrator Concord Company LP (industrial processes). We could not separate the quantities of the two sources. [b]Fuel oil is assumed to be residual fuel oil number 5. Fuel oil for the residential sector was an aggregate of distillate fuel oil and kerosene. [c]ND = no data. [d]NU = not used. [e]This value does NOT include the emissions from transmission and distribution losses. [f]Propane use was solely from Saint Paul's School.

Natural gas was the most used fuel source in the city. About 2.2 million MMBtu of natural gas was used in Concord (**Table 5.2**), contributing 35% to the emissions from the built environment (116,630 out of 337,944 MT CO_2e). The second most used source was electricity, where 1.3 million MMBtu contributed to 26% of emissions (88,501 out of 337,944 MT CO_2e).

Natural gas was also the most used fuel in residential areas (785,306 out of 1,755,089 MMBtu; 45%); however, distillate fuel oil and kerosene (22%), wood (8%), and propane (6%) are also used (**Table 5.2**). Interestingly, natural gas and fuel oil were both used more than an electric baseboard (325,952 out of 1,755,090 MMBtu; 19%).

Table 5.2: Energy use of electricity and stationary fuels in the community

Source	Commercial & Institutional	Municipal	Residential	Total Energy Use per Source
-	MMBtu	MMBtu	MMBtu	MMBtu
Electricity	900349	35745	325952	**1,262,046**
Fuel Oil[a]	120483	*NU*[d]	385794	**506,277**
Natural Gas	1346626	61406	785306	**2,193,338**
Propane	1343[f]	*NU*	113176	**114,519**
Wood	*ND*[b]	*NU*	144862	**144,862**
Total Energy Use per Sector	**2,368,802**[c]	**97,151**	**1,755,089**	**4,221,042**[c,e]

[a]Fuel oil is assumed to be residual fuel oil number 5. Fuel oil for the residential sector was an aggregate of distillate fuel oil and kerosene. [b]ND = no data. [c]This does NOT include the energy used by propane and municipal solid waste by the Wheelabrator Concord Company LP. [d]NU = not used. [e]This value does NOT include the energy lost from transmission and distribution. [f]Propane use was solely from Saint Paul's School.

The commercial and institutional sector released the most emissions in 2019 (**Figure 5.2**). More than sixty percent of emissions from the built environment were emitted by commercial and institutional activity (64%; 217,563 out of 337,994 MT CO_2e). The residential areas contributed 34% of the emissions (114,609 out of 337,944 MT CO_2e). However, without including the large energy generating facility in the commercial and institutional sector, these buildings only contribute 43% of emissions.

According to EPA FLIGHT, there is one large (emitting >25,000 MT CO_2e annually) energy generating facility in the city: the Wheelabrator Concord Company LP[37]. This waste-to-energy facility supports the electrical needs of 14,460 New Hampshire homes as well as its own operations by incinerating municipal solid waste. They also combust propane at the facility. In the latest reporting year (2018), Wheelabrator released 73,892 MT CO_2e of GHG emissions. This industrial facility contributed 15% to the total community-wide inventory emissions.

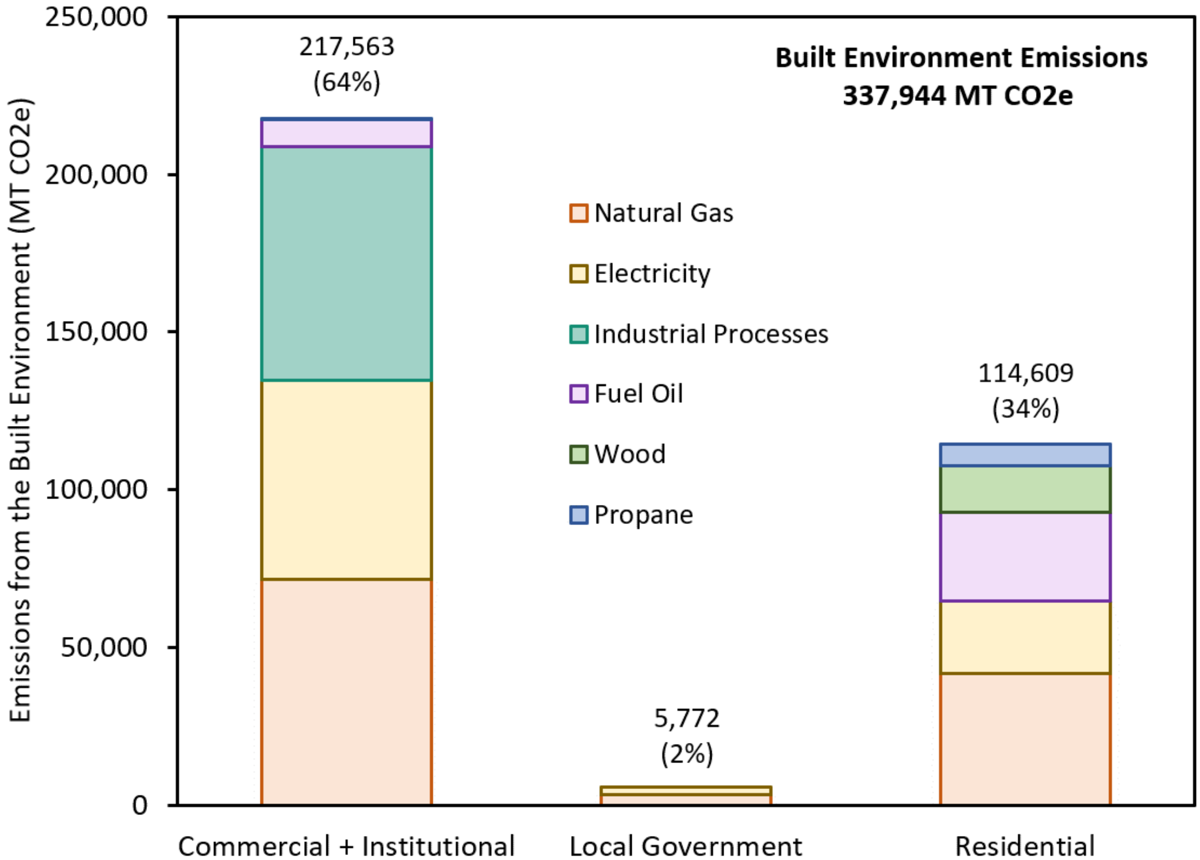

Figure 5.2: Estimated greenhouse gas emissions (MT CO_2e) emitted by fuels combusted and electricity used in the built environment in 2019. The commercial and institutional, local government, and residential sectors were considered city-wide. Industrial processes are included in the commercial and institutional sector, where they used propane and municipal solid waste. Legend is ordered from largest to smallest sources. Fuel oil was estimated as residual fuel oil number 5. This figure does NOT include emissions from transmission and distribution losses.

The top twenty. We received three aggregated numbers of kilowatt-hours consumed by the twenty highest consuming commercial and industrial businesses in Concord for 2017 (July 2017 to December 2017), 2018, and 2019. In 2019, these businesses contributed to about 17% of the total electricity use emissions in Concord (15,415 out of 88,501 MT CO_2e) [**Figure 5.3**]. With electricity use, we were able to break down the usage by five different sectors for the year 2019:

1. All commercial and industrial areas,
2. Institutions other than local government,
3. Local government operations,
4. Residential areas, and
5. Top twenty commercial and industrial users.

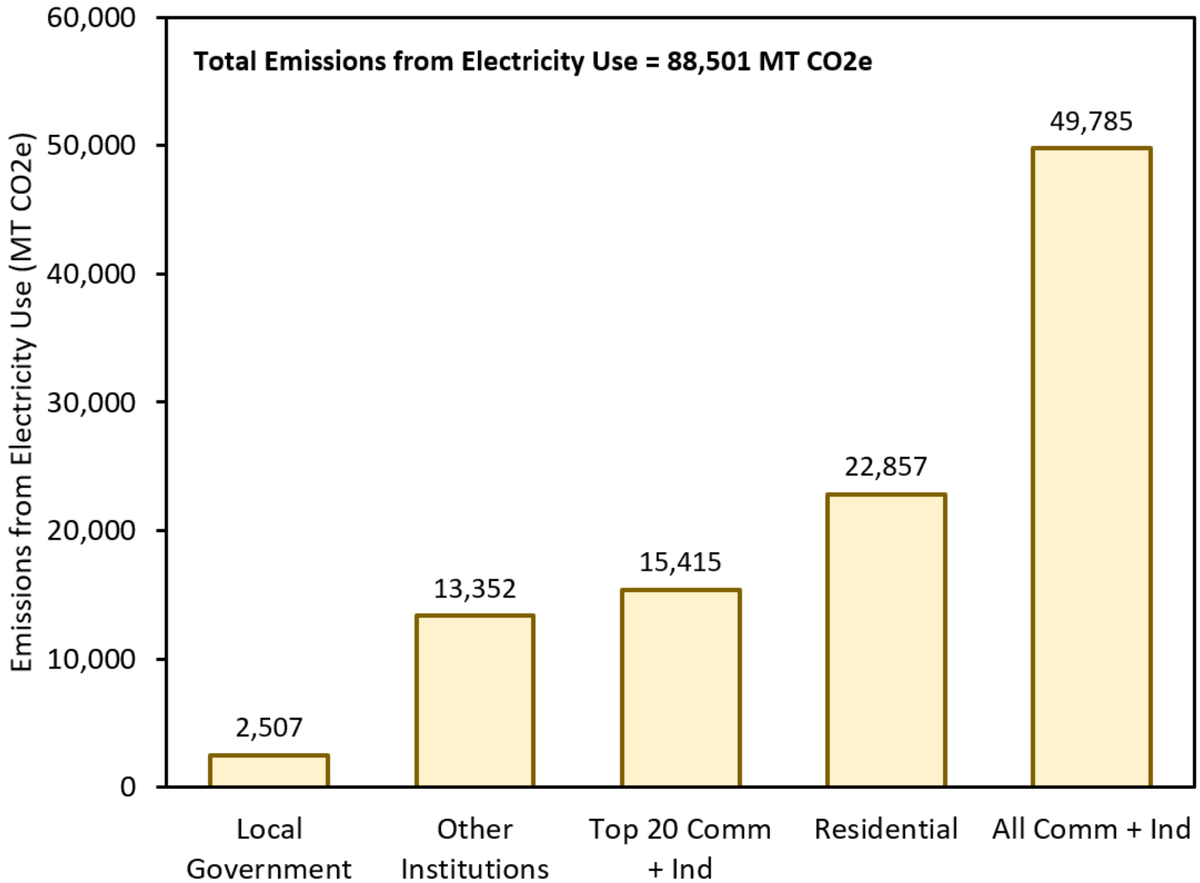

Figure 5.3: Estimated greenhouse gas emissions (MT CO_2e) emitted by electricity consumption by different community sectors in 2019. The local government, other institutions (*i.e.*, state government, public housing, and public schools), top twenty commercial and industrial (comm + ind) facilities, residential sectors, and all commercial and industrial facilities were considered city-wide. The "top twenty commercial + industrial" are included in "all commercial + industrial". The sectors are ordered by smallest to largest emissions released.

Farm Animals and Fertilizer Use

An estimated amount of 1,940 MT CO_2e of GHG emissions was released by farm animals and their associated manure in the Concord community in 2019. The farm animals considered were dairy cows and youngstock. Most of the emissions are from methane emitted by the animals themselves (96% or 1,870 out of 1,940 MT CO_2e) rather than their manure production.

Of the sources of data received, about 27 MT CO_2e of GHG emissions were released from fertilizer applied in the city in 2019.

Solid Waste Generation

In 2019, Concord emitted 11,211 MT CO_2e from 24,509 short tons of waste generated in the community. This waste was processed at a landfill in Bethlehem, NH. A little less than two-thirds of this tonnage was generated by commercial and industrial businesses (63%; 15,482 out of 24,509 short tons), emitting 7,082 MT CO_2e in GHGs (**Table 5.3**). An estimated 35% of emissions were released by the residential sector (3,923 out of 11,211 MT CO_2e). Exploring the average residential emissions, about 0.1 MT CO_2e of GHGs per person were released by landfilling waste.

Table 5.3: Summary of emissions and energy use from waste

Sector	Generated Waste	Energy	Emissions
-	Short tons	MMBtu	MT CO_2e
Commercial & Industrial[a]	15482	4153	7082
Municipal[b]	451	121	206
Residential[b]	8577	2301	3923
Total	**24,509**	**6,575**	**11,211**

These values were calculated in EPA WARM[31]. [a]Only businesses following the Solid Waste Flow Control Ordinance are included in this calculation. [b]These sectors were aggregated together. We estimated five percent of these aggregated emissions to be from municipal buildings.

Concord also composted and recycled waste from residential and municipal buildings in 2019. The city composted 1,630 short tons of leaf and yard waste and recycled 3,627 short tons of cardboard, single-stream recyclables, and curbside recyclables.

Transportation

Transportation comprises of emissions associated with the movement of people and goods, as well as service vehicles. Transportation is one of the largest sources of GHG emissions in most communities, and this trend can be seen in Concord, NH. Local governments have significant policy influence over some transportation emission sources, *e.g.*, passenger vehicles and public transit, but less control over others, *e.g.*, air travel and marine vessels[28].

In 2019, Concord emitted 137,371 MT CO_2e in GHGs, accounting for 28% of the total amount of community-wide inventory emissions. Most of the emissions came from vehicles registered by residents (87%; 119,705 out of 137,371 MT CO_2e) [**Table 5.4**]. The second largest source was vehicles used by commercial businesses. These vehicles were registered with the City by companies. Vehicles travelled an estimated 317 million miles.

Table 5.4: Summary of transportation emissions in Concord

Vehicle Group	Miles Travelled	2019 Emissions
-	Miles	MT CO_2e
City Vehicle Fleet	1,145,327[d]	1,546
Company Vehicles[a]	26,698,284	13,840
Concord Area Transit	196,099	266
Residential Vehicles[b]	287,425,130	119,705
School Vehicle Fleets[c]	1,386,523	2,014
Total	**316,851,363**	**137,371**

[a]Company vehicles are vehicles registered under a company. [b]Residential vehicles are vehicles registered by a person or unknown registration holder. [c]School bus fleets include the Concord and Merrimack Valley School Districts

and Saint Paul's School. [d]Not all City vehicles and equipment travelled on a road.

As explored in the **Vehicle Fleets** section, City vehicle and equipment fleets released 1,546 MT CO2e of GHG emissions in 2019.

Transit system. The Concord Area Transit (CAT) released 266 MT CO_2e of GHGs. CAT has a fleet of diesel- and a fleet of gasoline-powered buses, where the gasoline-powered buses emitted slightly more GHG emissions (**Table 5.5**). However, the gasoline-powered buses travelled an order of magnitude more miles than the diesel-powered buses.

Table 5.5: Summary of Concord Area Transit fleets

Vehicle Group	Fuel Consumed	Miles Travelled	Energy Use	Emissions
-	Gallons	Miles	MMBtu	MT CO_2e
Diesel-Powered Buses	10899	70790	1505	111
Gasoline-Powered Buses	17609	125309	2201	155
Total	**-**	**196,099**	**3,706**	**266**

School fleets. The Concord School District (CSD), Merrimack Valley School District (MVSD), and Saint Paul's School vehicle fleets emitted 2,014 MT CO_2e of GHGs (**Table 5.6**). These vehicles travelled about 1.4 million miles, consuming about 28,000 MMBtu of energy. The MVSD buses and vans emitted the most GHGs, but also travelled the most miles.

Table 5.6: Summary of school vehicle fleets

Vehicle Group	Fuel Consumed	Miles Travelled	Energy Use	Emissions
-	Gallons	Miles	MMBtu	MT CO_2e
Concord School District				
Diesel Buses	10899	70790	1505	501
Gasoline Buses	17609	125309	2201	192
Merrimack Valley School District				
Diesel Big Buses	95000	380000	13119	970
Gasoline Small Buses	12000	120000	1500	105
Gasoline Vans	5000	100000	625	44
Saint Paul's School				
Diesel Fleet	8037	104160	1110	82
Gasoline Fleet	13507	136826	1688	119
Total	**-**	**1,386,523**	**27,563**	**2,014**

Registered vehicles. In 2019, 41,045 registered vehicles released 133,545 MT CO_2e of GHG emissions in Concord. Gasoline was the most used fuel, where 14.3 million gallons of gasoline were combusted by registered vehicles (assuming hybrid vehicles combusted gasoline). Light trucks released nearly sixty percent of the emissions (59%; 78,964 out of 133,545 MT CO_2e) [**Figure 5.4**]. Passenger cars released the second most GHG emissions (33%).

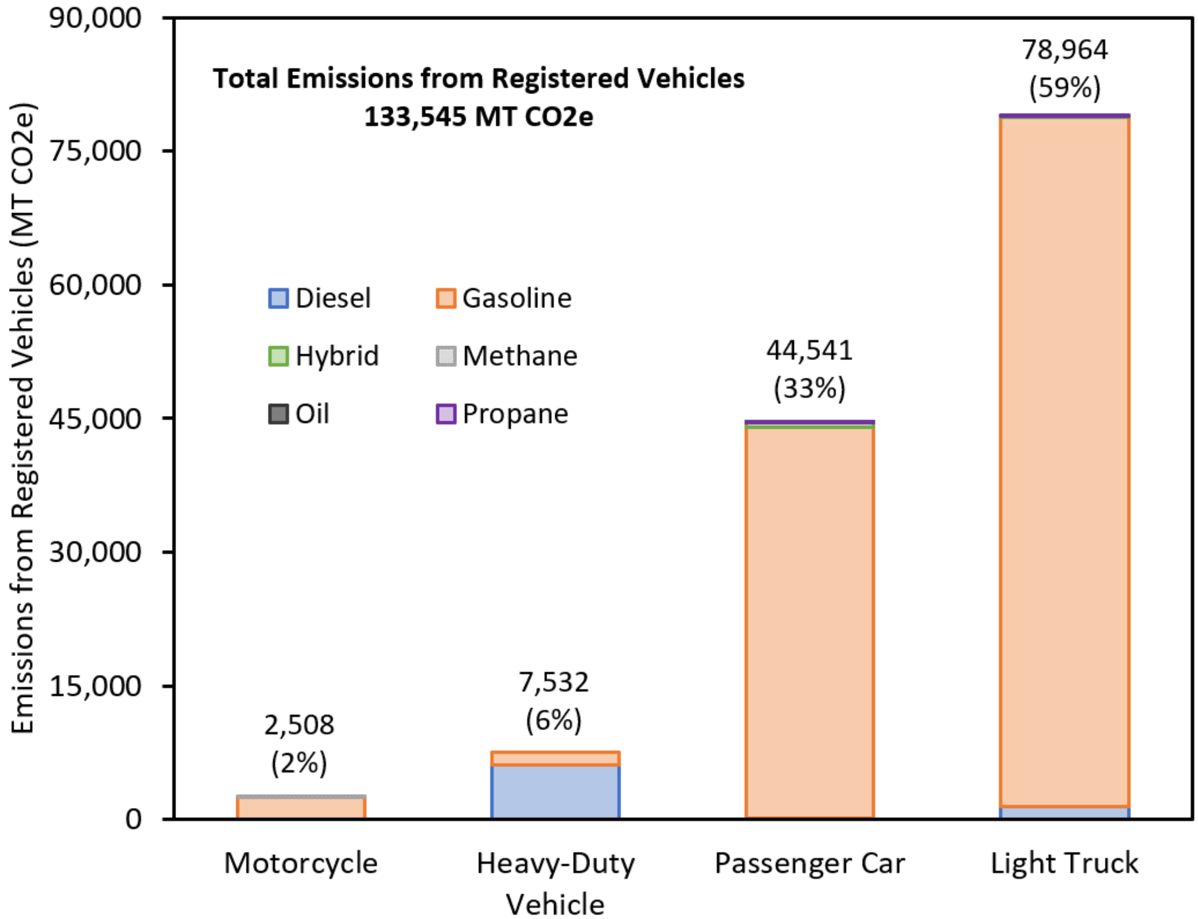

Figure 5.4: Estimated greenhouse gas emissions (MT CO_2e) emitted by registered vehicles in Concord in 2019. Vehicle types are listed on the x-axis. The "trailer" fuel type was assumed to be diesel for heavy-duty vehicles and was incorporated into that category. Hybrid vehicles were assumed to combust gasoline.

Most of the emissions from registered vehicles were from Concord residents (90%; 119,705 out of 133,545 MT CO_2e), whereas companies emitted only 10% of the emissions (13,840 out of 133,545 MT CO_2e).

Urban Forestry

Carbon sequestration secures carbon dioxide (CO_2) to prevent it from entering the Earth's atmosphere. This carbon sink is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change. Biological carbon sequestration is the storage of carbon dioxide in vegetation such as grasslands or forests, as well as in soils and oceans. Forests were considered in this inventory.

From the 2018 New Hampshire Town and Community Forests Survey[40], 12,462 MT CO_2e of carbon was sequestrated in Concord from 3,766 acres of forestland. This removal source reduced the gross GHG emissions by 2.5% (483,443 MT CO_2e of net emissions).

Predicting Future GHG Emissions

Returning to the Goals

The primary purpose of this report was to quantify the GHG emissions and removals in the city of Concord. These results will help the City of Concord government recommend strategies that are cost-effective, align with the city's energy and emissions commitments and global scientific GHG targets, progress towards the 100% renewable goal, engage stakeholders in reducing emissions, prioritize responsibilities for a sustainability staff member, and help develop a climate action plan.

The City committed to the following community-wide goals:

1. 100% of electricity consumed in Concord will come from renewable energy sources by 2030;
2. 100% of thermal energy (heating and cooling) consumed in Concord will come from renewable energy sources by 2050; and
3. 100% of transportation in Concord will be clean transportation by 2050[3].

Furthermore, according to the IPCC, global society will have to reduce CO_2 emissions by about 45% from 2010 levels by 2030, achieving net-zero CO_2 emissions around 2050[1]. The NH Climate Action Plan also recommended that New Hampshire strives to achieve long-term GHG emissions reductions of 80% below 1990 levels by 2050[4].

Emissions Projections

Climate action planning. To help the City add detail to these recommendations, we set up a climate action planning tool (the CURB Tool) with the community-wide inventory GHG emissions and EEAC's energy targets for 2030 and 2050. We also added 2025 as a halfway point between 2020 and 2030. This tool can be used to focus on key areas within our recommendations. It also can predict what Concord's emissions will look like in the future (**Figure 5.5**). Unfortunately, the tool was created using the Global Protocol for Community-Scale GHG Emission Inventories (GPC)[18], so some of the sources are grouped differently than with the US Community Protocol[28] used in this inventory.

From the 2019 community-wide estimate, GHG emissions are predicted to grow 11% by the year 2050 in Concord (**Figure 5.5**). As the city works to reduce its emissions, Concord's growing population must be considered as more emissions come with more people. By the year 2025, emissions are predicted to grow two percent.

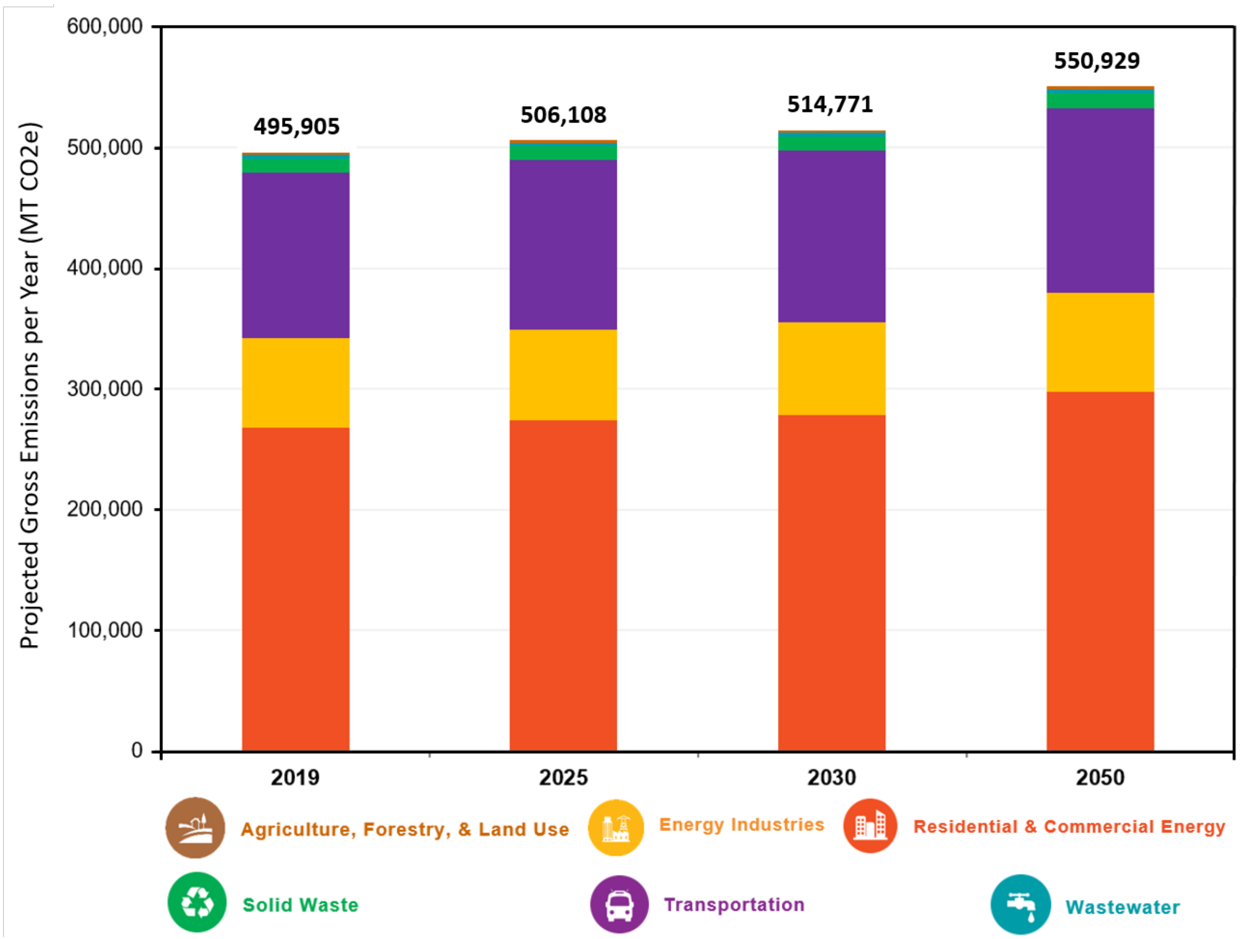

Figure 5.5: Projected gross greenhouse gases emissions (MT CO_2e) emitted by the Concord community from 2019 to 2025, 2030, and 2050 if no action occurs. Projections were based on population growth in Concord. This figure was adapted from the CURB tool[29].

Sourcing 100% of Concord's electricity from renewable suppliers by 2030 will not be enough to meet the IPCC's GHG target (45% GHG reduction from 2010 levels by 2030). To reduce emissions by at least 40% in 2030 (and stay on target for the EEAC's 100% renewable energy goal by 2050), Concord will also need to reduce transportation and stationary fuel emissions both by 35% from the 2019 estimates (**Figure 5.6**). These percentages apply if the city focuses on reducing electricity, stationary fuel, and transportation emissions. Also, emissions targets will not be met if we focus on one sector alone.

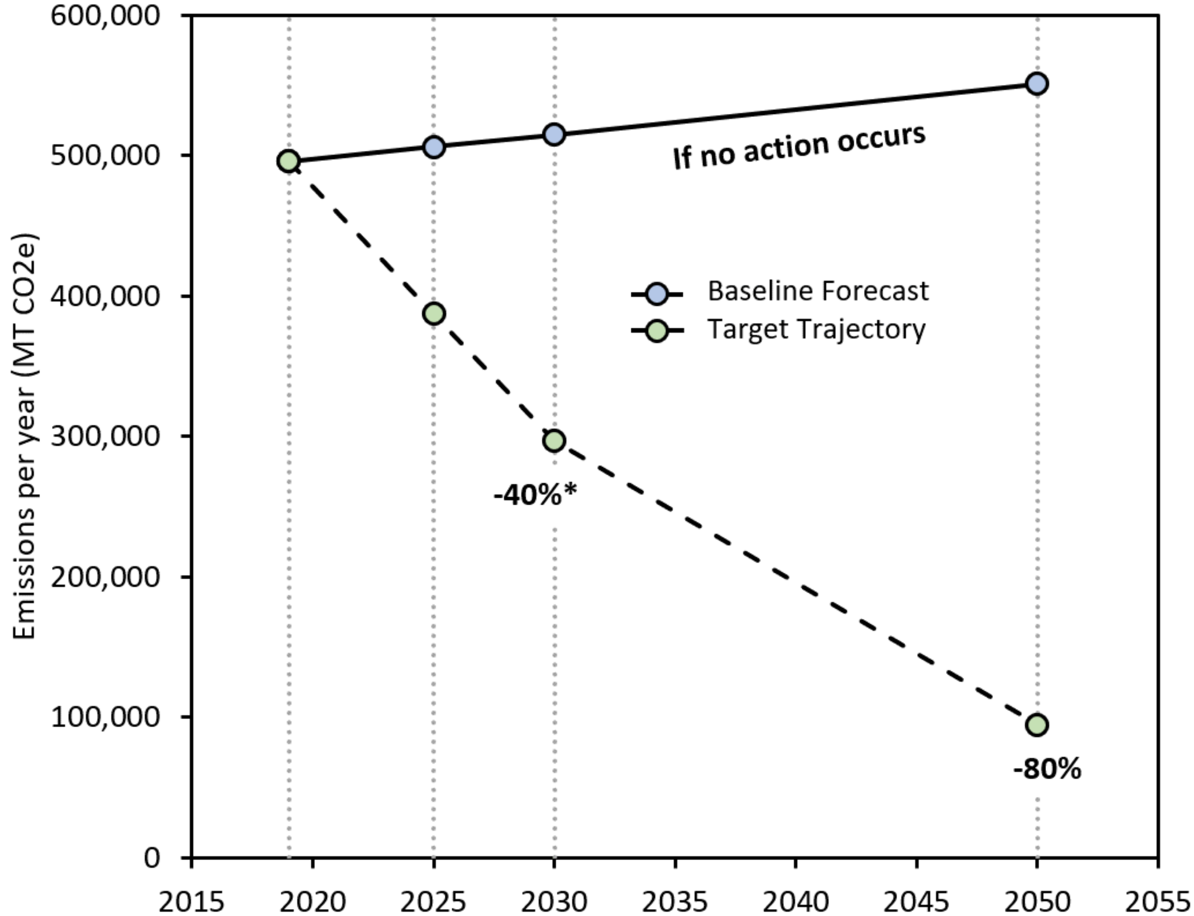

Figure 5.6: Baseline forecast and target trajectory of gross greenhouse gas emissions (MT CO_2e) projected to be released by the Concord community from 2019 levels to 2025, 2030, and 2050 if no action occurs and if the EEAC's renewable energy goals are met in 2050. The asterisked "-40%" assumes that, in addition 100% renewably-sourced electricity, 35% renewably-sourced thermal energy and 35% clean transportation will also be met in 2030. The grey dotted lines indicate 2019, 2025, 2030, and 2050. Projections were based on population growth in Concord. This figure was adapted from the CURB tool[29].

Reducing GHG Emissions

The EEAC's Strategies

Within each goal, the Concord Energy and Environment Advisory Committee (EEAC) identified several strategies to approach each goal in the drafted 2019 Strategic Plan[3]:

100% Renewable Electricity by 2030	
Strategy #1: Transition City government electricity consumption to 100% locally-generated renewable energy	Strategy #2: Prioritize making solar available to low and moderate income residents
Strategy #3: Streamline and clarify permitting processes to encourage installation of renewable energy projects within Concord's borders	Strategy #4: Offer local incentives for renewable energy projects where appropriate
Strategy #5: Serve as information resource for Concord residents and businesses seeking to generate their own renewable energy	Strategy #6: Convert grid power in Concord to 100% renewable electricity by municipal aggregation
Strategy #7: Advocate for state policy that helps Concord achieve its 100% renewable energy goal; participate in innovative utility programs	
100% Clean Transportation by 2050	
Strategy #1: Reduce vehicle miles travelled	Strategy #2: Prepare for the installation of electric vehicle charging infrastructure
Strategy #3: Transition City-owned vehicles to clean transportation	Strategy #4: Transition CAT buses over to clean transportation
Strategy #5: Encourage school districts in Concord to convert school buses to clean transportation	Strategy #6: Encourage and facilitate the transition to electric vehicles for the private sector
Strategy #7: Ensure electric vehicles are powered by renewable energy and minimize costs of charging	
100% Renewable Thermal Energy by 2050	
Strategy #1: Facilitate transition to renewable thermal sources by City government	Strategy #2: Facilitate transition of community member to replace old heating systems with renewable thermal resources
Strategy #3: Explore opportunities for district heating and co-generation	

Conversations on Social Justice

Considering social justice. In addition to keeping the EEAC's renewable energy strategies in mind, the University of New Hampshire Sustainability Fellow was tasked with considering the social justice impact of her work. This report considered how vulnerable populations (*i.e.,* senior citizens, low-income populations, renters, and New Americans) may benefit from any emissions strategies, initiatives, or programs produced from its findings. To approach this objective, we held conversations with community leaders in Concord, NH, to get a better picture of the social justice challenges related to energy and sustainability. A couple of the conversations are included in this report.

Barriers to self-sufficiency. According to the Refugee Processing Center, 193 refugees from around the world resettled in New Hampshire in 2019, where 79 resettled in Concord, NH[46]. Concord is a designated resettlement city. Resettlement is the careful selection by governments for purposes of lawful admission of the most vulnerable refugees who can neither return to their home country nor live in safety in neighboring host countries[47]. Resettlement is a life-saving solution for the most vulnerable refugees in the world. In Concord, Ascentria Care Alliance is the main volunteer agency that helps New Americans resettle. Ascentria works with refugees from 90 days to five years, depending on the services the refugee needs.

One of our conversations was with Amy Marchildon who is the director of Services for New Americans at Ascentria. We talked about Ascentria's program for New Americans, the diverse communities in Concord that happily welcome new faces, and some of the barriers New Americans face in relation to energy. The biggest barrier New Americans face is transportation. In the refugee program at Ascentria, one of the main goals is to become self-sufficient, *i.e.*, going to work.

Transportation to work is a typical barrier if the job is not within Concord. The Concord Area Transit does not provide service to surrounding cities and towns, but there are also some gaps in service within Concord as well. There is convenient service to the industrial sector and commercial downtown areas of Concord, but less to the rural areas. People may have to wait an hour or so when exchanging from bus to bus. The buses also stop running around 6:30 to 7:00 PM, which makes it difficult for people who use the transit system to get to two or more work shifts. However, Ascentria does help facilitate carpooling for their refugee clients to get people who work at same location to carpool together. In addition, we discussed how CAT has personalized training services for new riders, which is great for New Americans who use transit to get around the city.

Weatherizing the community. According to the American Community Survey, about 10% of the Concord population was in poverty in 2014 to 2018. Twelve percent of households received the Supplemental Nutrition Assistance Program (SNAP), and seven percent did not have health insurance coverage. About 46% of the population were renters, occupying apartments in multi-unit structures, and 6% of the population live in mobile homes.

Our second conversation was with Christopher Vought who is the director of Housing Rehabilitation and Energy Conservation at the Community Action Program (CAP). The US Department of Energy (DOE) and the US Department of Health and Human Services' (DHHS) Low Income Home Energy Assistance program (LiHEAP) funds the CAP's Weatherization Assistance Program (WAP) and Building Weatherization Program (BWP). The WAP and BWP assist low-income households by improving the safety and comfort of the home, while also focusing on energy reduction. In 2019, the CAP utilized about $2 million in funding to assist over 300 low-income homes in improving energy efficiency, comfort levels, and quality of life. Forty-five inoperable or unsafe heating systems were replaced with high efficiency equipment.

Chris spoke about how years ago, there was a stigma attached to CAPs for food, energy savings, and transportation, so there was not a lot of marketing. People did not want others to know they were applying for help, and these programs were usually heard through word of mouth. Today, there is more marketing and knowledge about CAPs; however, rural areas may be unexplored. There are five Community Action Programs in New Hampshire. Through making homes more energy and fuel efficient, homeowners save money and reduce their energy usage.

One of the biggest questions that arose from our conversation was, "How can we move towards renewable and sustainable systems?" One of the options the Community Action Program does not offer through its energy and fuel efficiency programs is solar power. Can incentive programs for solar on residential homes and apartment buildings be created?

Recommended Strategies

Based on the community-wide inventory results, EEAC's proposed strategies, and the conversations on social justice, we recommend these main emissions reduction strategies.

Build the capacity for electric vehicle charging in Concord. In 2019, 48 registered vehicles were electric vehicles in Concord (**Table 3.7**), which is 21 vehicles higher than 2018. Electric vehicles are an important part of meeting global goals on climate change. Electric vehicles are responsible for considerably lower emissions over their lifetime than conventional vehicles. The City can encourage electric vehicle purchasing (both new and secondhand vehicles) by businesses and residents in Concord. The City can also provide incentives for buying electric vehicles and provide educational materials on their benefits.

Expand community transit and sustainable transportation. In addition to electric vehicles, the community should consider developing more bike lanes, better walkability in Concord, and an expanded transit system. Walking and biking provide a clean and healthy source of community transportation. A travel demand strategy centered on walking, biking, and transit has the potential to significantly reduce transportation emissions[48]. Cities, such as Portland and Minneapolis, have invested in active transportation infrastructure. A recent study by the University of Minnesota tracking the progress of this investment found that roughly 20% of all trips in Minneapolis are currently taken by walking and biking[48]. When transit is considered, the statistic jumps to nearly 28%[48].

Furthermore, providing more bus route coverage around Concord (*i.e.*, dense apartment areas and rural areas), providing bus stops in the surrounding communities, and increasing bus route hours on the weekdays will make the Concord Area Transit more accessible and reduce single-occupancy vehicle usage.

Identify emissions from the largest commercial buildings. The commercial, industrial, and institutional sector (labelled commercial + institutional in figures) contributed 50% to the total amount of community-wide emissions. The City can work with, encourage, and promote businesses and industries as leaders in developing strategies to reduce their emissions. A list of the largest commercial buildings and questions on emissions areas of interest is discussed in the **A Bottom-Up Approach** section below.

Identifying and working with industries in Concord may also significantly reduce emissions. The method used to estimate industrial processes (USCP BE.8.1) has its limitations. The data available from the US EPA Mandatory Reporting Rule will not provide a complete accounting of all process emissions in Concord. Any facility that emits under the 25,000 MT CO_2e per year threshold will not be among the sources available from EPA FLIGHT. However, it is possible to identify industries in the community that may fall under the EPA reporting threshold and directly request GHG data from them. The EPA publishes a data table of non-GHG pollutant by facility that can be useful in identifying major industries in your community. The National Emissions Inventory Facility Emissions Summaries (NEI) do not contain information about GHGs, but they do show sources of other emissions in your community by North American Industry Classification System (NAICS) code. The NAICS codes will show the type of industry, so if there are cement producers, steel manufacturers, or other likely GHG emitters in your community that fall below the EPA's mandatory reporting threshold for GHGs, you may be able to find them in this data source and contact them directly for information.

Include vulnerable communities in climate action planning. Just transition is when cities design and deliver climate actions in an inclusive and equitable way to serve the whole community without compromising economic prosperity[49]. The need to identify and engage stakeholders and particularly hard-to-reach groups is important so the City can understand and address the root causes and drivers of disproportionate climate risk and consider how the climate action process can be more inclusive[49]. As the City engages vulnerable populations (*i.e.*, low-income residents, New Americans, renters, and senior citizens), a few principles may be considered, including[49]:

- *Being transparent*: Objectives of the engagement process should be clearly communicated to stakeholders. Seek to avoid over-promising actions where possible.
- *Partner with the community to deliver change*: Only through involving communities in the process will the City develop the most innovative and impactful climate change actions. Go beyond the town-hall style meeting and partner with widespread volunteer programs.
- *Treat engagement as a process, not an endpoint*: The City should build on previous community engagement and improve the relationship with its community over time. This can be achieved through tracking, measuring, and reporting on stakeholder engagement to understand what is effective and what is not working well.

C40's "Inclusive Community Engagement: Executive Guide" and "Inclusive Climate Action in Practice" reports are great resources to start[49,50].

Furthermore, 2020 UNHSI Sustainability Fellow Carly Peruccio created a website for the City of Keene, NH, Energy Plan for the public to get involved and learn about what the City of Keene is doing[51]. This website added transparency to the energy plan and engaged the Keene community on climate change and energy efficiency. This website is great example for virtually engaging with the Concord community. You can access the website at https://www.keeneenergyplan.com/[51].

Invest in and protect forests and other natural areas. Carbon sequestration can reduce carbon dioxide in the atmosphere. Trees and other plants help cool the environment, making vegetation a simple and effective way to reduce urban heat islands[52]. An urban heat island occurs when a city experiences much warmer temperatures than nearby rural areas. The different in temperature between urban and less-developed rural areas has to do with how well the surfaces in each environment absorb and hold heat. The use of trees and vegetation in the urban environment brings benefits beyond mitigating urban heat islands, including[52]:

- *Reduced energy use*: Trees and vegetation that directly shade buildings decrease demand for air conditioning.
- *Improved air quality and lower greenhouse gas emissions*: By reducing energy demand, trees and vegetation decrease the production of associated air pollution of greenhouse gas emissions. They also remove air pollutants and store and sequester carbon dioxide.
- *Enhanced stormwater management and water quality*: Vegetation reduces the runoff and improves water quality by absorbing and filtering rainwater.
- *Improved quality of life*: Trees and vegetation provide aesthetic value, habitat for many speiceis, and can reduce noise.

Planting urban trees and protecting forests can serve as a significant carbon removal source (**Table 4.11**).

Invest in a transition to solar and wind power in the region. The City can provide educational materials and resources to make it easy for homeowners and business owners to switch to renewable sources. For example, Unitil has the option for customers to choose a preferred energy supplier. Certain energy suppliers available provide a percentage or full amount of energy from renewably generated sources. The City can also provide incentives or opportunities for rooftop solar on residential buildings for homeowners and apartment complex owners or landlords.

Promote composting and recycling. The city can encourage responsible waste disposal for residents and provide incentives for responsible waste disposal in commercial businesses. Composting and recycling can reduce greenhouse gas emissions, and local governments have a high degree of influence in this area. Significant emissions reductions can occur in the following ways[53]:

- Recycling avoids upstream GHGs emitted in raw material acquisition, manufacture, and transport of virgin inputs and materials;
- Recycling of wood and paper products increases the amount of carbon stored in forests; and
- Recycling and composting reduce emissions associated with landfilling and/or combustion of wastes.

In 2013, ICLEI created a Recycling and Composition Emissions Protocol to estimate the associated emission and reductions[53].

Reduce stationary fuel consumption in all sectors. The City can reduce its use of stationary fuels by weatherizing old buildings, upgrading energy efficiency in buildings, and transitioning to new heating technologies. They can also promote the Community Action Program's and Unitil fuel efficiency programs and the EEAC's weatherizing campaign, retrofit old buildings, and reduce idling in the community.

Next Steps

This inventory establishes the baseline GHG emissions for the Concord community. Moving forward, Concord should take steps to reduce emissions focused on stationary fuel, transportation, and electricity use. A few years later (possibly 2025), an updated GHG inventory should be conducted to benchmark any progress towards the EEAC's 100% renewable energy goal.

Fill in the Gaps

Defining the baseline greenhouse gas emissions in Concord have helped us understand (1) the data that goes into inventories from a top-down approach and (2) the sources and sectors that contribute the most emissions. Most importantly, this project made clear the new directions needed to understand the Concord community's climate impact. Key questions that emerge for the commercial, industrial, and residential sectors include:

1. What commercial businesses and industries have the largest carbon footprint? What strategies can we explore together to reduce their impact?
2. What products and services do households consume?
3. What unsustainable practices occur in residential areas? Can we work towards more sustainable practices together?

Answering these questions will move this phase I community-wide inventory towards a bottom-up approach that invites input from the community, ultimately working towards Concord's 100% renewable energy goal.

Some other directions and emissions sources to consider in a future community-wide inventory include:

- **Food consumption**. This inventory looks at the cumulative emissions associated with the transportation, waste, and production of food supplied to the community.
- **Land use and land management**. This source of carbon emissions and removals looks at how developed and natural areas of Concord increase and reduce emissions.

- **Refrigerant and fire suppressant leakage**. Many chemicals commonly used in refrigeration, fire suppression equipment, and other produces can contribute to global warming. This source could contribute significant emissions to the community-wide total.

A Bottom-Up Approach

Surveying Commercial Businesses

We faced many limitations while conducting this inventory, where we estimated emissions, especially in the commercial and residential sectors, from state and national data sources. It is not clear which commercial businesses emit the most GHGs from this study. One way to explore this knowledge gap is to conduct a commercial business survey. This survey will engage businesses and identify the commercial buildings with the largest carbon footprints in Concord, ultimately working towards reducing their GHG emissions.

A tentative commercial business survey should include questions on stationary fuel consumption, electricity use, vehicle fleets, and sustainable practices. For example, questions may include:

<u>Stationary Fuels</u>

- What heating fuels does your company consume at this building? Fuels can include but are not limited to coal, kerosene, natural gas, propane, fuel oil (distillate or residual), wood.
- Is annual consumption data available for these fuels? If so, how much fuel was consumed in 2019?

<u>Electricity Use</u>

- Does your company consume electricity at this building? If so, who is the electricity provider?
- How much electricity was used in 2019?
- Does your company source your electricity from renewable sources? Were you aware of this preferred energy supplier option? If so, what renewable sources does your company utilize?

<u>Transportation</u>

- Does your company have a vehicle fleet? If so, what types of vehicles are used (*e.g.*, passenger cars, vans, SUVs, pickup trucks, buses, or heavy-duty vehicles)?
- Do you know how many vehicles per type are used?
- What fuel types do these vehicles use (*e.g.*, diesel, gasoline, electricity, etc.)?
- How much fuel was consumed for each vehicle type? How many miles travelled?

<u>Sustainability Practices</u>

- Has your company implemented any sustainable initiatives or programs? If so, what were they?

A list of businesses with the largest building square footage has been curated from the Mergent Intellect database (**Table 5.7**). Seven businesses have buildings greater than or equal to 90,000 square feet in Concord, NH. Sixteen businesses have buildings between 50,000 and 90,000 square feet.

Table 5.7: Largest commercial businesses in Concord, NH

Company Name	SIC Code
Building size greater than or equal to 90,000 square feet	
Concord Hospital, Inc.	80620000
Automotive Supply Associates, Inc.	50130100
New Hampshire Distributors, LLC.	51819902
Concord Litho Group, Inc.	27520101
United Church of Christ Retirement Community, Inc.	65139903
Capital Region Health Care Corp.	58120313
Walmart Inc.	53119901
Building size between 50,000 and 90,000 square feet	
The Granite Group Wholesalers LLC.	50750200
Central Supply Company	50740200
Newspapers of New England, Inc.	27110101
Saint Paul's School	82110204
Newspapers of New Hampshire Inc.	27110100
Sabbow and Co., Inc.	87480000
Capitol Plumbing & Heating Supply Co., Inc.	50740000
Healthsouth Rehabilitation Hospital	80939903
Granite State Management & Resources	61119906
Electropac Co., Inc.	36720000
Concord Family YMCA	86410300
New Hampshire Higher Education Assistance Foundation	61630000
Health Club of Concord LLC.	79910102
Lee B Marden	42250000
State of New Hampshire	91110203
Unitil Energy Systems, Inc.	49119901

Businesses were searched for through the Mergent Intellect database by building size. SIC is standard industrial classification. This list was curated in July 2020.

Surveying Household Consumption

Consumption-based accounting. Consumption-based greenhouse gas accounting is an alternative to the scope-based (*i.e.*, scope one or direct emissions; scope two or indirect emissions) approach to measuring city GHG emissions. This focuses on the consumption of goods and services (*e.g.*, food, clothing, electronic equipment, etc.) by residents of a city. GHG emissions are reported by consumption category rather than GHG emission source category.

The consumption-based approach captures direct and lifecycle GHG emissions of goods and services—including those from raw materials, manufacture, distribution, retail, and disposal—and allocates GHG emissions to the final consumers of those goods and services, rather than to the original producers of those GHG emissions[54]. In a simple equation:

$$Consumption = Production - Export + Import$$

C40 Cities developed a report, presenting the methodology and results of a study investigating the consumption-based GHG emissions from 79 cities[54]. In addition, the Town of Philipstown, NY, conducted a community GHG emissions inventory, which considered consumption-based emissions from households[55]. Both resources are great places to start. Example topics to consider may include:

- Utilities and housing
- Food, beverage, and tobacco
- Public and private transport
- Clothing, furnishing, and household equipment
- Restaurants, hotels, recreation, and culture
- Communications
- Education and health

Customizing this inventory to suit Concord's goals and needs is a great way:

- To understand the sustainable and unsustainable practices or activities Concord residents perform;
- To understand what community programs or sustainable options are being utilized, *i.e.*, Community Action Program fuel efficiency program or Unitil's preferred energy supplier choice; and
- To engage and connect with the Concord community.

Create the Climate Action Plan

A climate action plan is a strategic document (or series of plans and documents) that demonstrates how a city will deliver on its commitment to address climate change[56]. In the context of the Paris Agreement, C40 defines a climate action plan as outlined below[56]:

1. Develop a pathway to deliver an emissions neutral city by 2050 and set an ambitious interim target or carbon budget;
2. Demonstrate how the city will adapt and improve its resilience to the climate hazards that may impact the city now and in future climate change scenarios;
3. Engage with the community to inform the plan, outline the social, environmental, and economic benefits expected from the plan, and establish ways to ensure equitable distribution of their benefits to the city's population;
4. Detail the city's governance powers and capacity as well as identify the partners who need to be engaged in order to accelerate the delivery of the city's mitigation targets and resilience goals.

Revisiting CURB. To help the progress of developing a climate action plan, we set up the CURB Tool (Climate Action for Urban Sustainability). This toolkit was designed to help guide cities through the process of planning and implementing a range of actions to reduce energy use, save money, and cut local greenhouse gas (GHG) emissions[29]. The technology and policy actions covered by CURB can also help deliver important local quality of life benefits, including improved air quality, local economic development and job creation[29].

C40's "Climate Action Planning Framework" is another great resource to start[56].

Community-Wide Inventory Summary Table

Table 5.8: Summary of 2019 community-wide inventory emissions and removals

Source -	Commercial + Industrial MT CO_2e	Municipal MT CO_2e	Residential MT CO_2e	Total Emissions MT CO_2e
Electricity Use	63137	2507	22857	**88,501**
Farm Animals	1939	0	0	**1,939**
Fertilizer Use	15	11	0	**27**
Industrial Processes	73892	0	0	**73,892**
Solid Waste Generation	7082	206	3923	**11,211**
Natural Gas	71607	3265	41758	*116630*
Fuel Oil	8845	0	28321	*37165*
Propane	83	0	7020	*7104*
Wood	0	0	14652	*14652*
All Stationary Fuels	80451	3265	91752	**175,551**
T&D Losses	3082	122	1116	**4,321**
CAT – Diesel	111	0	0	*111*
CAT – Gasoline	155	0	0	*155*
City Vehicle Fleet – CNG	0	1	0	*1*
City Vehicle Fleet – Diesel	0	810	0	*810*
City Vehicle Fleet – Gasoline	0	735	0	*735*
School Fleets – Diesel	1553	0	0	*1553*
School Fleets – Gasoline	460	0	0	*460*
Registered Vehicles	13840	0	119705	*133545*
All Transportation	16120	1546	119705	**137,371**
Urban Forestry	-	-	-	**-12,462**
Wastewater Treatment	0	3093	0	**3,093**
Community-Wide Emissions	**245,802**	**10,750**	**239,353**	**495,905 (483,443)**

The net community-wide emissions are in parentheses. CAT is Concord Area Transit. CNG is compressed natural gas. T&D is transmission and distribution.

6. Wrapping It Up

Closing Remarks

Revisiting the importance. With this report, the city of Concord takes the next step in fighting climate change. This report looks at greenhouse gas emissions and removals at the local government scale and the community-wide scale, providing a holistic picture on the city's sources of achievement and improvement. These inventories highlight ways the City of Concord government and EEAC can enhance their approach and develop data-driven educational materials, initiatives, and policy.

List of Acronyms

ACS	American Community Survey
CAP	Community Action Program
CAT	Concord Area Transit
CBECS	EIA Commercial Buildings Energy Consumption Survey
CDD	Cooling Degree Days
CO_2e	Carbon Dioxide Equivalent
COMF	Combined Operations Maintenance Facility
CSD	Concord School District
DOE	US Department of Energy
DOS	Department of Safety
DOT	Department of Transportation
EEAC	Energy and Environment Advisory Committee
eGRID	Emissions and Generation Resource Integrated Database
EIA	US Energy Information Administration
EPA	US Environmental Protection Agency
FLIGHT	EPA Facility Level Information on Greenhouse Gasses Tool
GHG	Greenhouse Gas
HDD	Heating Degree Days
HVAC	Heating, Ventilation, and Air Conditioning
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hours
LGGIT	Local Greenhouse Gas Inventory Tool
LGO	Local Government Operations
LGOP	Local Government Operations Protocol
mcf	Thousand cubic feet
MMBtu	Million British Thermal Units
MVSD	Merrimack Valley School District
MWh	Megawatt-Hours
NAICS	North American Industry Classification System
NH	New Hampshire
NHDES	New Hampshire Department of Environmental Services
NOAA	National Oceanic and Atmospheric Administration
REC	Renewable Energy Certificate
RPS	Renewable Portfolio Standard
SEDS	State Energy Data System

T&D	Transmission and Distribution
TDD	Total Degree Days
UNH	University of New Hampshire
USCP	United States Community Protocol
VMT	Vehicle Miles Travelled
WARM	Waste Reduction Model
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

Glossary of Key Terms

Activity data	A quantitative measure of a level of activity that results in greenhouse gas (GHG) emissions. Activity data is multiplied by an emission factor to derive the GHG emissions associated with a process or an operation. Examples of activity data include kilowatt-hours (kWh) of electricity used, quantity of fuel used, and distance traveled.[18]
Base year	A historical datum (*e.g.*, year) against which a city's emissions are tracked over time.[18]
BASIC	An inventory reporting level that includes all scope 1 sources except from energy generation, imported waste, industrial processes and product use (IPPU), and agriculture, forestry, and other land use (AFOLU), as well as all scope 2 sources.[18]
British Thermal Unit	The standard unit used to assess how much energy different fuels use.
Climate Action Plan	A strategic document (or series of plans and documents) that demonstrates how a city will deliver on its commitment to address climate change.[56]
CO_2 equivalent	The universal unit of measurement to indicate the global warming potential (GWP) of each GHG, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate the climate impact of releasing (or avoiding releasing) different GHGs on a common basis.[18]
Double counting	Two or more reporting entities claiming the same emissions or reductions in the same scope, or a single entity reporting the same emissions in multiple scopes.[18]
Emission	The release of GHGs into the atmosphere.[18]
Emission factor(s)	A factor that converts activity data into GHG emissions data (*e.g.*, kg CO_2e emitted per liter of fuel consumed).[18]
Enteric fermentation	A natural part of the digestive process in ruminant animals, such as cattle, sheep, goats, and buffalo. Microbes in the digestive tract, or rumen, decompose and ferment food, producing methane as a by-product.[57]
Global warming potential	A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one unit of CO_2.[18]
Greenhouse gases (GHGs)	GHGs are the seven gases covered by the United Nations Framework Convention on Climate Change (UNFCCC): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).[18]
Greenhouse gas inventory	A GHG inventory estimates the quantity of GHG emissions and removals associated with community sources taking place during a chosen year.
Proxy data	Data from a similar process or activity that is used as a stand-in for the given process or activity without being customized to be more representative of that given process or activity.[18]
Reporting year	The year for which emissions are reported.[18]

Resettlement	The careful selection by governments for purposes of lawful admission of the most vulnerable refugees who can neither return to their home country nor live in safety in neighboring host countries[47].
Scope 1 emissions	GHG emissions from sources located within the city boundary.[18]
Scope 2 emissions	GHG emissions occurring because of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.[18]
Scope 3 emissions	All other GHG emissions that occur outside the city boundary because of activities taking place within the city boundary.[18]
Sector	A segment of the community in which data is aggregated.

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