2019 Greenhouse Gas Emissions Inventory Brief 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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A special thanks to the University of New Hampshire Sustainability Institute and the project mentors in Concord, NH, for their commitment and insight.

Picture of the Turtle Statue from visitconcord-nh.com.

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LIST OF ACRONYMS

ACS	American Community Survey
CAT	Concord Area Transit
"City"	Referred to as the City of Concord NH government
CURB	Climate Action for Urban Sustainability
DEI	Diversity, Equity, and Inclusion
EEAC	Energy and Environment Advisory Committee
EIA	US Energy Information Administration
EPA	US Environmental Protection Agency
FLIGHT	EPA Facility Level Information on Greenhouse Gasses Tool
GHG	Greenhouse Gas
GPC	Global Protocol for Community-Scale GHG Emission Inventories
IPCC	Intergovernmental Panel on Climate Change
LGGIT	Local Greenhouse Gas Inventory Tool
LGO	Local Government Operations
LGOP	Local Government Operations Protocol
kWh	Kilowatt-Hour
mcf	Thousand Cubic Feet
MMBtu	Million British Thermal Units
MT CO_2e	Metric Tons of Carbon Dioxide Equivalent
REC	Renewable Energy Certificate
T&D	Transmission and Distribution
UNH	University of New Hampshire
USCP	US Community Protocol for Accounting and Reporting of GHG Emissions
WARM	EPA Waste Reduction Model
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

1. EXECUTIVE SUMMARY

According to the Intergovernmental Panel on Climate Change, 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]. 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, NH, 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 caused 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), and the Douglas N Everett Ice Arena. Then, 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 for building heat in particular caused 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.

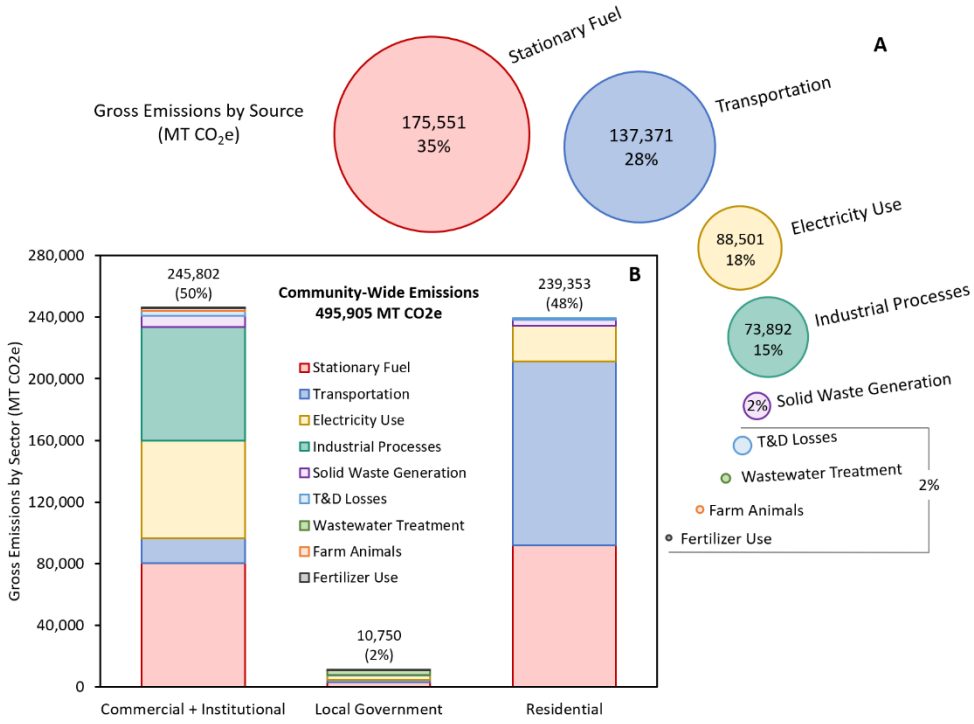

Figure 1.1: Estimated gross GHG emissions (MT CO_2e) emitted by each community source (**A**) and sector (**B**) in 2019. **Figure 1.1A** shows the percent of gross emissions for the five largest sources and sums the emissions of the four smallest sources. **Figure 1.1B** shows the total amount and percentage of gross emissions for each sector (*i.e.*, commercial + institutional, local government, and residential). T&D is transmission and distribution. Commercial + institutional includes industrial facilities.

2. PURPOSE

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 2.1**). The city spans 64 square miles with quite a few natural areas to explore: more than 80 miles of trails, 21 parks, and 7 community pools[5]. Concord also offers a vibrant performing arts scene, commerce center, and medical hub.

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 is $62,967.

Striving Towards 100% Renewable Energy

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]. 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[6]. New Hampshire, specifically, has experienced the negative impacts of climate change, such as rising temperatures, 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].

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

- Embracing the NH Climate Action Plan to reduce greenhouse gas 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].

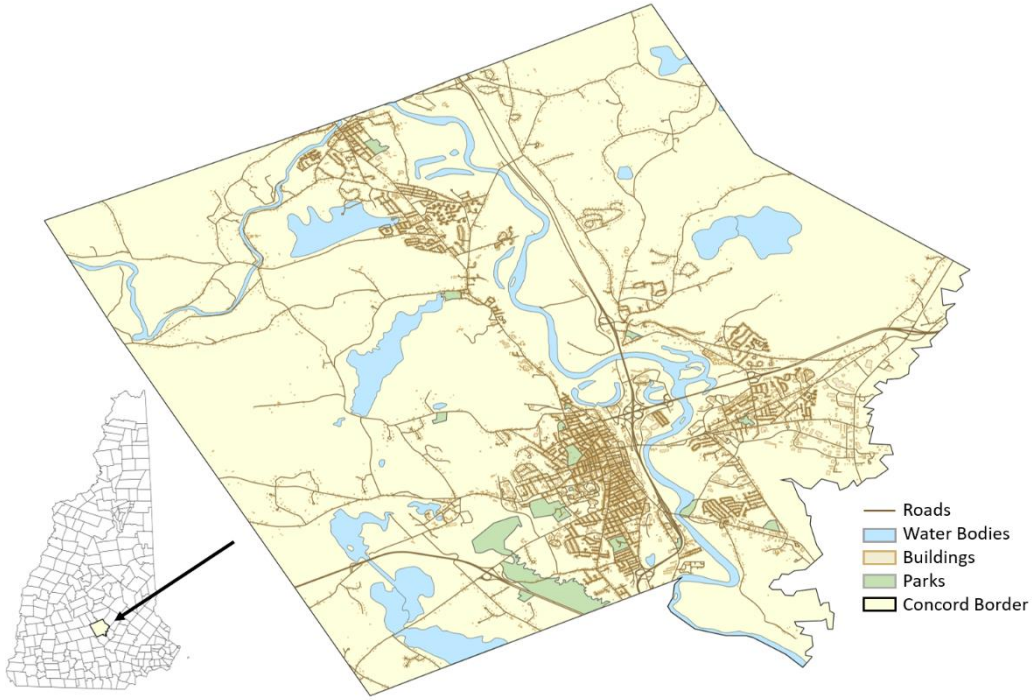

Figure 2.1: Map of Concord, NH. Roads were clipped from the 2020 NH Public Roads shapefile from NH GRANIT[7]. Water bodies were clipped from the 2010 (updated 2019) USA Detailed Water Bodies layer package from ESRI[8]. Buildings were clipped from the 2018 (release 1.1) NH Building Footprint GeoJSON from Microsoft[9]. Parks were clipped from the 2010 (updated 2019) USA Parks layer package from ESRI[10]. The Concord Border was clipped from the 2018 NH counties shapefile from the US Census.

The strategic plan. In July 2018, the City 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's Energy and Environment Advisory Committee (EEAC) drafted the 100% Renewable Energy Goal Strategic Plan to achieve these goals[3]. The strategic plan identified greenhouse gas (GHG) emissions tracking and interim targets as an important component of successful implementation[3].

What has been done. Previously, the EEAC conducted a community-wide carbon footprint analysis on 2018 electricity usage, 2019 thermal consumption of natural gas, and 2018 transportation. 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
- The renewable energy certificates (RECs) purchased by the municipal government offset 100% of electricity-related GHG emissions.

The next step the EEAC identified was to conduct a comprehensive GHG emissions inventory to account for other GHG sources in the community (*i.e.*, household heating fuel, solid waste generation, and wastewater treatment) using a standardized and replicable methodology.

The next step. A GHG inventory estimates the quantity of GHG emissions and removals associated with community sources taking place during a chosen year[11]. 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.

Diversity, Equity, and Inclusion

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.

How are greenhouse gases measured?

Gases that trap heat in the atmosphere are called greenhouse gases (GHG). There are six gases typically considered in GHG inventories:

1. Carbon dioxide (CO_2)
2. Methane (CH_4)
3. Nitrous oxide (N_2O)
4. Hydrofluorocarbons (HFCs)
5. Perfluorocarbons (PFCs)
6. Sulfur hexafluoride (SF_6)

These gases are measured and reported in metric tons of carbon dioxide equivalent (MT CO_2e). A metric ton is roughly the same mass as a small car!

GHG emissions are often measured in carbon dioxide equivalent (CO_2e). To convert emissions of a gas into CO_2e, its emissions are multiplied by the gas' Global Warming Potential (GWP)[12]. The GWP considers the fact that many gases are more effective at trapping heat per unit mass than carbon dioxide[12].

Picture of the CO_2 CUBE art installation by PUSH_ARCHITECTURE, representing a metric ton of CO_2.

3. DATA COLLECTION

Determining What to Measure

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 (**Figure 3.1**):

1. Local government operations, and
2. Community-wide accounting.

In GHG 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 (LGO). This inventory used the methods provided by the Local Government Operations Protocol (LGOP) version 1.1, which was released by The Climate Registry[13]. This inventory focused on emissions the City 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[13].

Community-wide accounting. This inventory used the methods provided by the US Community Protocol for Accounting and Reporting of GHG Emissions (USCP) version 1.2, which was released by the ICLEI – Local Governments for Sustainability[11]. This inventory focused on community emission and removal sources the City may address through policy, projects, and stakeholder outreach—providing the City with the opportunity to tell a unique story on GHG sources of community interest. In phase I of its execution, this inventory will act as a working framework for a more comprehensive community-wide inventory in the future.

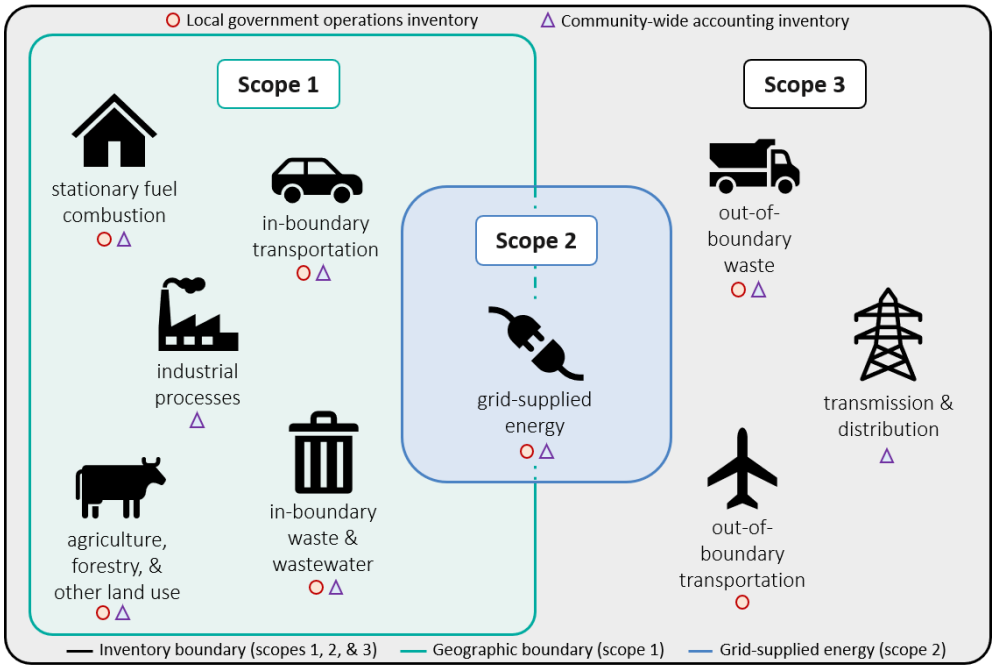

Figure 3.1: The scopes, sources, and boundaries of GHG emissions explored in each inventory. The sources included in each inventory are marked by the red circle (Local Government Operations Inventory) and the purple triangle (Community-Wide Inventory). This figure was adapted from the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories[14].

Greenhouse Gas Accounting Tools

Three different 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[15]. CURB version 2.1 was used to project GHG emissions from 2019 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[16]. The tool's February 2020 update was used to compile two GHG inventories for the entire community and for local government operations.

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[17]. WARM version 15 was used to calculate GHG emissions from waste generation in Concord.

Emission and Removal Sources

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. Supplemental information on data collection and emissions estimates can be found in our **Detailed GHG Inventory Report**.

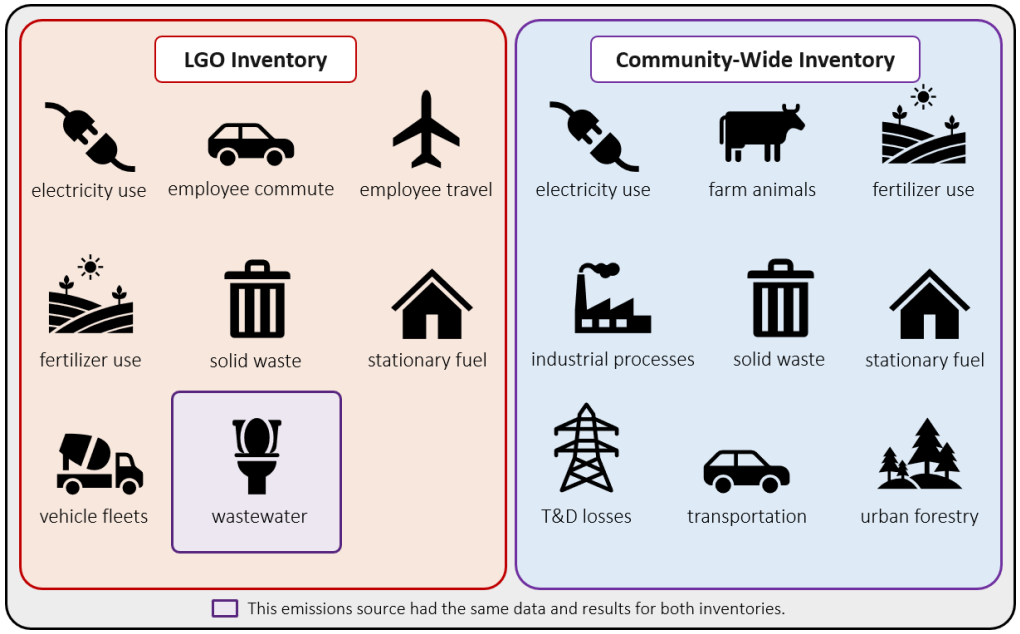

Figure 3.2: Greenhouse gas emission and removal sources included in each inventory. Wastewater treatment is explained in the Local Government Operations (LGO) Inventory, but it is also included in the Community-Wide Inventory emissions total. T&D is transmission and distribution.

Challenges and Limitations

Throughout this report, we faced multiple obstacles in collecting data, preparing data, and estimating emissions, which limited the analysis we could conduct. We stated all these challenges in our **Detailed GHG Inventory Report**. Some notable challenges and limitations include:

- Refrigerant leakage, fire suppressant, and other fugitive emissions in buildings and vehicles were not included in either inventory.
- Some state and national data from previous years were used, which may not represent the most valid estimates for 2019 GHG sources.
- Wastewater treatment and farm animal estimates must be interpreted with uncertainty because we had to estimate the populations served by the facilities and the populations of animals.

4. LOCAL GOVERNMENT OPERATIONS INVENTORY

Results

Overview

In 2019, we estimated that the City's local government operations (LGO) released 12,049 metric tons of carbon dioxide equivalent (MT CO_2e) in GHG emissions. In this inventory, we explored emissions from eight different sources under operational control (**Figure 3.2**).

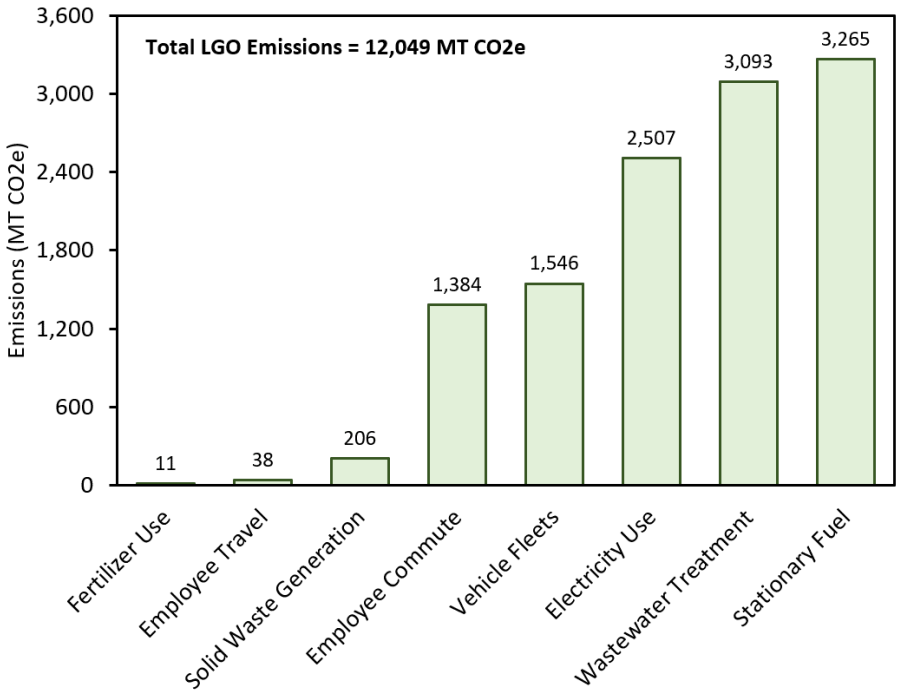

Figure 4.1: Estimated greenhouse gas emissions (MT CO_2e) emitted by each local government operations (LGO) source in 2019. The number above each bar is the total amount of emissions for the source. The sources are in order of increasing amount of emissions.

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), and the Douglas N Everett Ice Arena. Furthermore, the City should focus on reducing emissions from vehicle fleets and employees commuting to work.

This report focused on the five largest emission sources in the City government. Additional results and reduction strategies can be found in our **Detailed GHG Inventory Report**.

Stationary Fuel Combustion

Emissions from stationary fuel was the largest source of GHGs. Natural gas was the only fuel used in City facilities in 2019. The City consumed about 59,700 thousand cubic feet (mcf) of natural gas, releasing 3,265 MT CO_2e in GHGs (**Table 4.2**). This fuel contributed 27% to the total amount of LGO inventory emissions.

Table 4.2: 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 ($)[a]	157,813

mcf is thousand cubic feet. MMBtu is million British thermal unit. MT CO_2e is metric tons of carbon dioxide equivalent.
[a]The US EIA 2019 average natural gas spot price of $2.57 per MMBtu was used to calculate energy cost[18].

Electricity Use

Emissions from electricity use were the third largest source of the City's greenhouse gases. In 2019, City facilities released 2,507 MT CO_2e, accounting for 21% of the total amount of LGO inventory emissions. The City consumed about 10.5 million kilowatt-hours of electricity (**Table 4.1**).

Table 4.1: 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 ($)[a]	1,780,473.92

kWh is kilowatt-hour. MMBtu is million British thermal unit. MT CO_2e is metric tons of carbon dioxide equivalent. [a]The average May 2019 price of electricity to NH customers of $0.17 per kWh was used to calculate energy cost[19].

Purchasing green energy. In 2019, the City purchased about 10.5 million kilowatt-hours (kWh) of electricity in the form of renewable energy certificates (RECs). These RECs cost an estimated total of $9,426 for the year; however, they fully offset the City's electricity use. The City's RECs were sourced from 100% wind power. To ensure as little double counting as possible, the emissions reduction from RECs were not included in the LGO emissions total[13].

Which energy source did City facilities use more?

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 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).

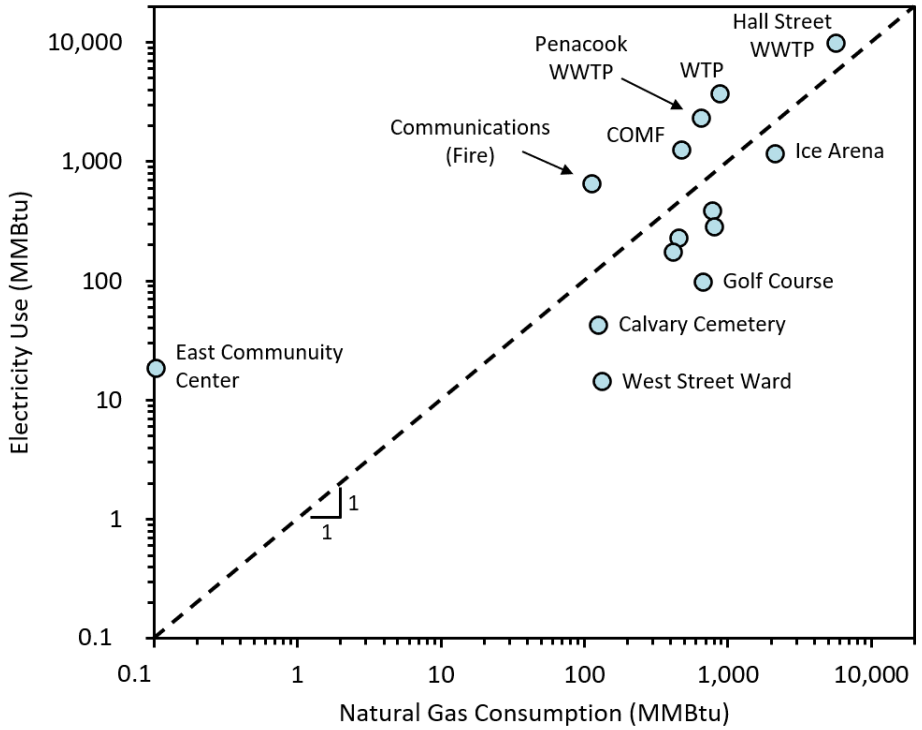

Figure 4.2: Energy use of electricity (MMBtu) as a function of the energy use of natural gas (MMBtu) emitted by a sample of 14 City government facilities in 2019. Both axes are on a logarithmic scale. The black dashed line is the one-to-one line, where facilities above the line use more electricity and facilities below the line use more natural gas. COMF is Combined Operations Maintenance Facility. WTP is water treatment plant. WWTP is wastewater treatment plant.

Wastewater Treatment Processes

Wastewater treatment was the second largest source, contributing 26% to the total amount of LGO inventory emissions. The City operates two WWTPs: (1) the Hall Street WWTP, and (2) the Penacook WWTP. In 2019, the Hall Street and Penacook WWTPs emitted 3,093 MT CO_2e in methane and nitrous oxide. Surprisingly, most of the emissions were from individual domestic septic tanks processed at the Hall Street WWTP (89%; 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[20].

Vehicle Fleets

In 2019, 222 vehicles were used by the City, where 48 of them were construction, recreation, or utility equipment. Five out of thirteen divisions used City vehicles: (1) Community Development, (2) Fire Department, (3) General Services, (4) Parks and Recreation, and (5) Police.

City vehicle fleets emitted 1,546 MT CO_2e in GHGs, accounting for 13% of the total amount of LGO inventory emissions. General Services released the most emissions (48%; 741 out of 1,546 MT CO_2e), followed by the Police (24%; 364 out of 1,546 MT CO_2e) and the Fire Department (20%; 315 out of 1,546 MT CO_2e) [**Table 4.3**]. The fuel cost for the vehicle fleet and equipment used by the City was $326,910.

Table 4.3: Summary of City vehicle fleets and equipment use

Division	**Vehicles Used**	**Fuel Cost**	**2019 Emissions**
-	Count	$	MT CO_2e
Community Development	7	5,857.25	27
Fire Department	32	65,581.45	315
General Services	122	154,838.95	741
Parks and Recreation	21	21,155.46	98
Police	40	79,476.81	364
Total	**222**	**326,909.92**	**1,546**

MT CO_2e is metric tons of carbon dioxide equivalent. Fuel consumption is not included in this table due to the different types of fuel each division's vehicles used.

Employee Commute

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

We found that an estimated 1,384 MT CO_2e were released in 2019 due to City staff commuting to and from work. General Services emitted the most emissions (314 MT CO_2e), followed by the Police (297 MT CO_2e) and the Fire Department (248 MT CO_2e). Although these divisions emitted the most GHGs, they also have the most active staff members. The emissions per City employee were estimated at 2.4 MT CO_2e per employee.

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. Employee commute contributed 11% to the total amount of LGO inventory emissions.

Reducing GHG Emissions

We recommend these main emissions reduction strategies:

- **Audit City facilities for refrigerants and other fugitive emissions**. Refrigerant leakage and fire suppressant may be significant sources.
- **Convert electricity sources to solar and wind**. Invest in new sources in Concord and the surrounding areas to improve energy security.
- **Convert natural gas consumption to electricity**.
- **Electrify City fleets and build electric charging infrastructure**.
- **Encourage efficiency in employee commuting**. Promote working from home days, carpool and vanpool programs, transit, biking and walking, and electric vehicle purchasing programs.
- **Invest in City-owned forests**. Carbon sequestration can reduce carbon dioxide in the atmosphere.
- **Reduce energy use in City facilities, prioritizing the highest users**. Conduct energy audits and improve energy efficiency in facilities. Weatherizing facilities can increase heating fuel efficiency and save money.

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 first. 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.

5. COMMUNITY-WIDE INVENTORY

Results

Overview

In 2019, we estimated that the Concord community released 495,905 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 (including industrial facilities) 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. Surprisingly, only two percent of the gross emissions were from local government (10,750 out of 495,905 MT CO_2e). In this inventory, emissions from the local government sector were estimated using a different protocol than in the **Local Government Operations Inventory**, so it excluded a couple emission sources accounted for at the community scale.

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.

This report focused on the six largest emission and removal sources in the community. Additional results are in our **Detailed GHG Inventory Report**.

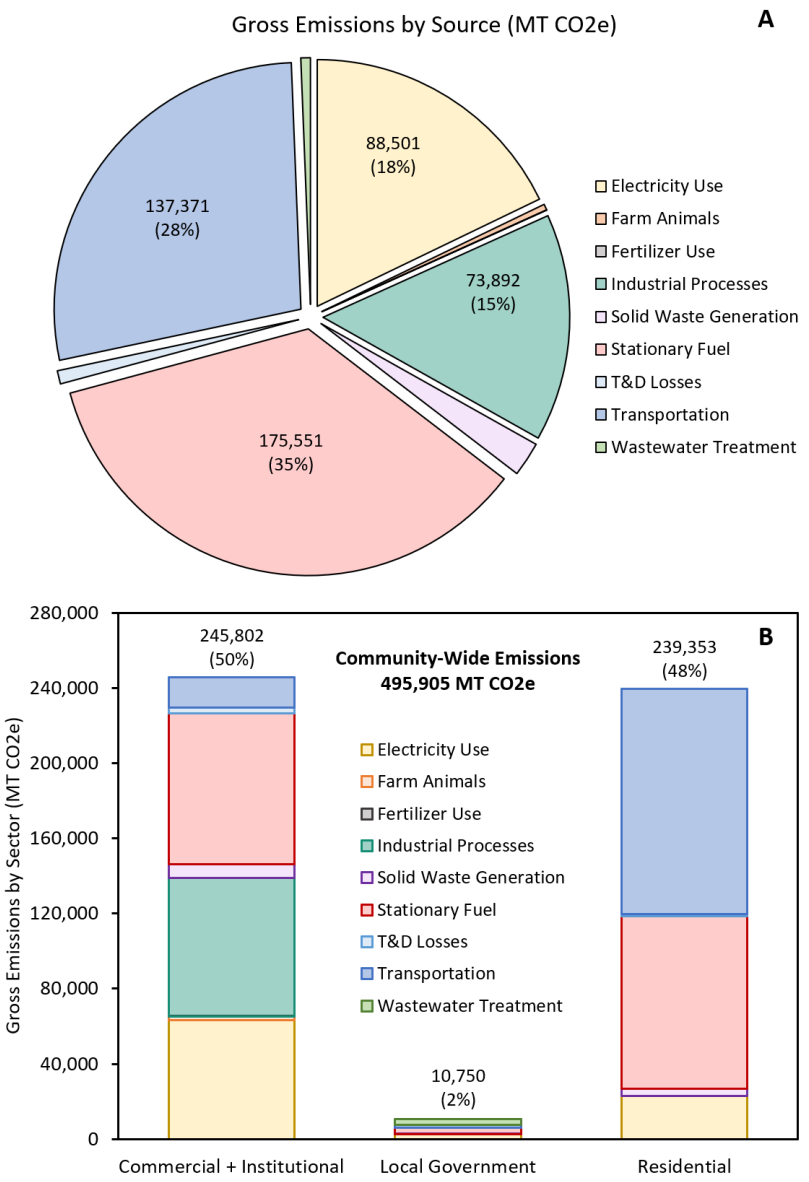

Figure 5.1: Estimated gross GHG emissions (MT CO_2e) emitted by each community source (**A**) and sector (**B**) in 2019. **Figure 5.1A** shows the total amount and percentage of gross emissions for the four largest sources. **Figure 5.1B** shows the total amount and percentage of gross emissions at the top of the bar for each sector (*i.e.*, commercial + institutional, local government, and residential). A similar figure is in the **Executive Summary** with proportional symbols.

Stationary Fuel

Concord used several stationary fuels in 2019, including fuel oil, natural gas, propane, and wood (**Figure 5.2**). The community released 175,551 MT CO_2e of GHGs from these fuels, where natural gas was released the most (66%; 116,630 out of 175,551 MT CO_2e). Stationary fuels contributed 35% to the total amount of community-wide emissions.

Transportation

Local governments have significant policy influence over some transportation emission sources, *i.e.*, passenger vehicles and public transit. In 2019, Concord emitted 137,371 MT CO_2e in GHGs, accounting for 28% of the total amount of community-wide emissions. Most of the emissions came from vehicles registered by residents (87%; 119,705 out of 137,371 MT CO_2e) [**Table 5.1**]. Vehicles travelled an estimated 317 million miles.

Table 5.1: Summary of transportation emissions in Concord

Vehicle Group -	Miles Travelled Miles	2019 Emissions 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.

Electricity Use

In 2019, Concord consumed about 370 million kilowatt-hours (kWh) of electricity, releasing 88,501 MT CO_2e in GHGs. The commercial and institutional sector accounted for two-thirds of the emissions from electricity use (71%; 63,137 out of 88,501 MT CO_2e) [**Figure 5.2**]. Electricity use contributed 18% to the total amount of community-wide emissions.

Industrial Processes

Industrial facilities that emit over 25,000 MT CO_2e must report their emissions to the EPA under the Mandatory Reporting Rule. In Concord, the Wheelabrator Concord Company LP meets those requirements[21]. This waste-to-energy facility incinerates municipal solid waste and combusts propane. In the latest reporting year (2018), Wheelabrator released 73,892 MT CO_2e in GHGs, contributing 15% to the community-wide emissions.

What sources were used in the built environment?

The built environment includes the living and working spaces provided for human activity[11]. GHG emissions include operational processes and human activities within those spaces as well as electric vehicle use[11].

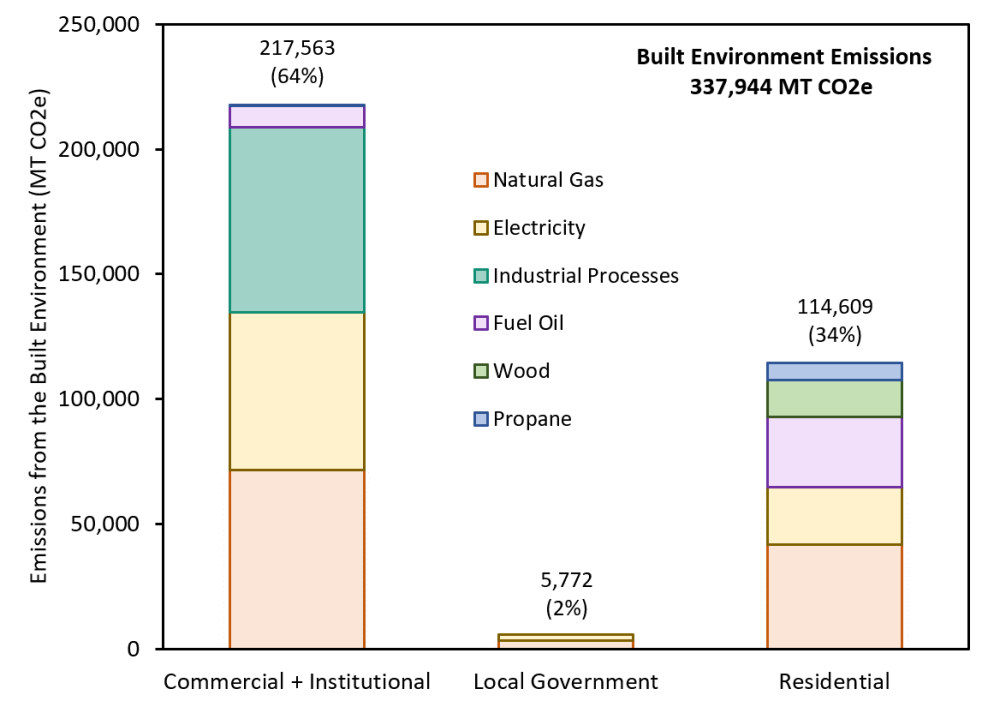

Figure 5.2: Estimated greenhouse gases emissions (MT CO_2e) emitted by fuels and electricity used in the built environment in 2019. Industrial processes include emissions from propane combustion and municipal solid waste incineration. Legend is ordered from largest to smallest emission sources.

Urban Forestry

From the 2018 New Hampshire Town and Community Forests Survey[22], 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).

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 businesses, industry, and institutions (63%; 15,482 out of 24,509 short tons).

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.

What is in your household waste?

Where does it go? In 2019, the Concord community produced 24,509 short tons of waste that was landfilled. This waste was processed at a 51-acre Casella Waste Systems landfill in Bethlehem, NH. This landfill is in the process of creating one of the first largest renewable energy projects by using landfill gas to supply renewable fuel to 90,000 homes and businesses in NH.

What is in my waste? Household waste consists of organic and inorganic waste. Organic waste includes kitchen waste, garden waste, and paper, which accounted for 41% of municipal solid waste landfilled in the US in 2017[23]. Food waste in particular contributed 22% of the municipal solid waste[23].

When organic waste decomposes, carbon dioxide and methane gas are created[24]. Methane is created when there is no air present, while carbon dioxide is the natural product when anything rots in air[24].

Inorganic waste does not directly contribute to GHG emissions unless it is incinerated. However, it does represent GHGs emitted during the manufacturing process[24]. All manufactured goods use natural resources, such as water, fuel, metal, and timber in their production—and this results in the emission of GHGs, particularly carbon dioxide and other pollutants[24].

Reducing GHG Emissions

We recommend these main emissions reduction strategies:

- **Invest in a transition to solar and wind power in the region**. Provide educational materials and resources to make it easy for homeowners and business owners to switch to renewable sources.
- **Reduce stationary fuel consumption in all sectors**. Weatherizing old buildings, upgrading energy efficiency in buildings, and transitioning to new heating technologies will help.
- **Build the capacity for electric vehicle charging in Concord**. Encourage electric vehicle purchasing by businesses and residents in Concord.
- **Identify emissions from the largest commercial buildings**. Work with and promote these businesses as leaders in developing strategies to reduce their emissions.
- **Invest in and protect forests and other natural areas**. Carbon sequestration can reduce carbon dioxide in the atmosphere.
- **Promote composting and recycling**. Encourage responsible waste disposal for residents and provide incentives for responsible waste disposal in commercial businesses.

Predicting Future GHG Emissions

Climate action planning. To help the EEAC 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 5.3**). Unfortunately, the tool was created using the Global Protocol for Community-Scale GHG Emission Inventories (GPC)[14], so some of the sources are grouped differently than with the US Community Protocol[11] used in this inventory.

From the 2019 community-wide estimate, GHG emissions are predicted to grow 11% by the year 2050 in Concord (**Figure 5.3**). 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.

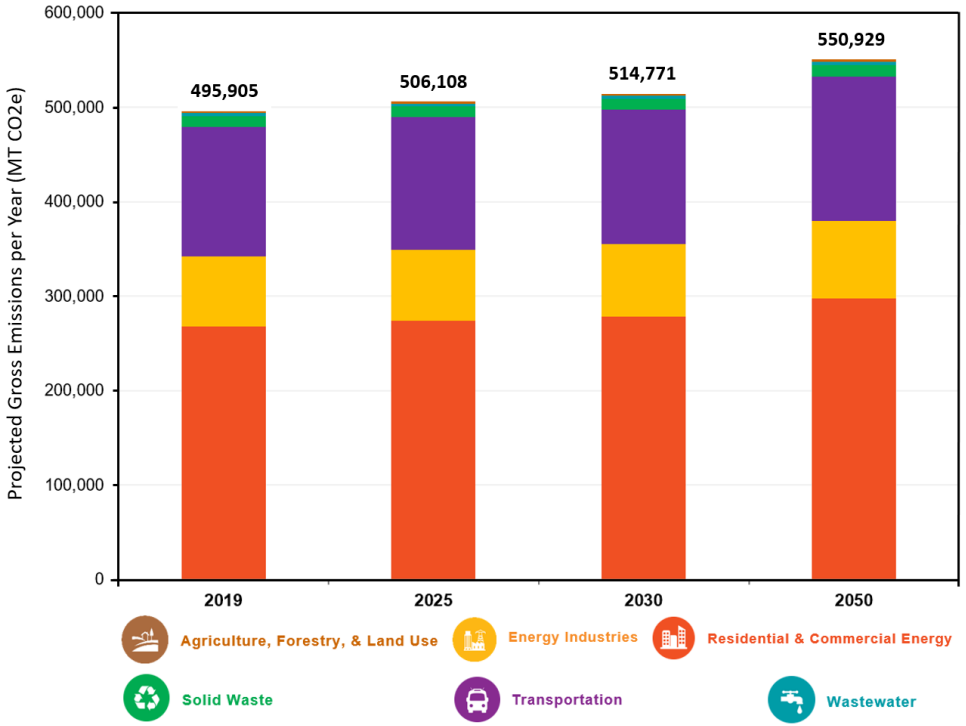

Figure 5.3: Projected gross greenhouse gases emissions (MT CO_2e) emitted by the Concord community from 2019 to 2025, 2030, and 2050 if no action occurs. Projections were based on population growth in Concord. This figure was adapted from the CURB tool[15].

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].

Sourcing 100% of Concord's electricity from renewable suppliers by 2030 will not be enough to meet the IPCC's GHG target. 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. 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. More information on emissions projections and recommendations can be found in our **Detailed GHG Inventory Report**.

Next Steps

This inventory establishes the baseline GHG emissions for the Concord community. Moving forward, Concord should take steps to reduce emissions from 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

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. Our **Detailed GHG Inventory Report** includes a list of businesses in Concord with the largest square footage and the commercial business survey.

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.
- **Household consumption**. This inventory looks at the cumulative emissions associated with the entire life cycle of products and services purchased by households. A survey can also engage residents in reducing their consumption.
- **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 products can contribute to global warming. This source could contribute significant emissions to the community-wide total.

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SELECTED APPENDICIES

Local Government Operations Inventory Summary Table

Table SA1: 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.

Community-Wide Inventory Summary Table

Table SA2: Summary of 2019 community-wide inventory emissions and removals

Source -	Commercial + Institutional MT CO_2e	Local Government 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.