City of Greenville, NC Greenhouse Gas Accounting and Emissions Reduction Plan

by
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Executive Summary

As we near the International Panel on Climate Change's 2030 deadline to halve global greenhouse gas (GHG) emissions, cities are being called upon to proactively manage the negative effects of urbanization. Greenville, North Carolina aims to join the growing list of American cities who are taking responsibility for their role in climate change by generating a comprehensive inventory of the GHGs emitted by their municipal operations. Our team's objective was to catalog the city's greenhouse gas footprint and make recommendations according to our findings, working in coordination with the City Manager of Greenville, NC. Specifically, we were tasked with creating an emissions inventory that could be used as the city's baseline, against which future years' inventories could be measured and compared to track reductions over time.

We produced a baseline GHG emissions inventory of municipal operations from fiscal year 2019, as that was the most recent fiscal year which experienced no operational interruptions from the Covid-19 pandemic. The inventory identifies activities and sectors with high emissions contributions, and we used this data to recommend the emissions reductions measures that would be most beneficial to the city. Our GHG emissions accounting methodology utilized the standardized framework for local governments created by ICLEI's Cities for Climate Protection Campaign. Using ClearPath—ICLEI's GHG emissions inventory tool—we generated an emissions report which includes an emissions inventory, projections of future emissions, and forecasts that predict the effects various potential reduction measures might have on Greenville's GHG footprint over a 10-year period. The emissions report contributed to the development of a sustainability project work plan with benchmarks and targets to track municipal emissions reduction performance over time.

Key Findings:

1. The majority of Greenville's emissions are Scope 1, or direct emissions from operational activity.
2. The greatest contributing sector of municipal operations to the city's emissions inventory is Vehicle Fleet. In this instance, "Vehicle Fleet" encompasses both municipal vehicles and transit vehicles, though future inventories should distinguish between the vehicle types to better target possible areas for emissions reductions.

3. Greenville's emissions per capita for municipal operations are not directly comparable to other North Carolina municipalities. The City of Greenville does not have operational control over some activities and sectors included in their peers' inventories of government operations.

Key Recommendations:

1. Implement energy efficiency improvements within Greenville's vehicle fleet to reduce the sector's contribution and the overall emissions footprint for municipal operations.
2. Disaggregate data into individual records within ClearPath to better understand which activities by sector have the largest contribution to better select emissions reduction measures.
3. If data is available, use the same process to generate a 2005 emissions inventory for the purposes of setting goals and measuring progress.
4. Continue the momentum from this project by making sustainability a permanent fixture within city operations through the hiring of a sustainability professional.

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I. Introduction

Greenville is a thriving hub in the eastern region of North Carolina. It is home to East Carolina University and the Greenville Convention Center and has expanding art, music, and culinary scenes and has a population over 95,000 residents (Greenville, North Carolina Population 2022.). The city continues to grow and has been listed on numerous "Best of" lists in the past 10 years. While urbanization produces growth and development benefits, cities are being called upon to proactively manage the negative effects of urbanization.

Greenville aims to join the growing list of American cities who are taking responsibility for their role in climate change by generating a comprehensive inventory of the greenhouse gases emitted by their municipal operations. Greenhouse gases (GHGs) trap and re-absorb heat from the sun within Earth's atmosphere and are vital in keeping the planet's climate habitable for humans and all other life forms as we know them. Beginning with the Industrial Revolution, greenhouse gas emissions started increasing at an alarming rate due to the burning of fossil fuels which has resulted in an accumulation of GHGs beyond their natural balance in the atmosphere. The warming effect of GHGs results in drastic changes to the climate system that are felt on local and global scales (What Are the Trends in Greenhouse Gas Emissions...).

Cities collectively account for about 60% of global energy-related greenhouse gas emissions ("Global Infrastructure Trends"). This is expected to increase to 76% by 2030 according to an estimation by the International Energy Agency (IEA), with some sources claiming that upward of 80% of anthropogenic GHG emissions are directly attributable to urban areas.[3] With these kinds of statistics, it is critical that municipal governments become more aware of their contributions to climate change so that they can begin to enact changes which will lessen their overall footprint. Ultimately, all urban residents will need to make reductions as well if urban areas want to truly lower their footprint. However, by first understanding their own contributions to emissions and strategies for reduction, city governments can set an example and be better prepared to enact regulations that are achievable and beneficial to all constituents. Having a baseline GHG emissions inventory is crucial for comparing future inventories and measuring future progress to evaluate the effectiveness of implemented strategies in emissions reduction. The baseline inventory is also used as the standard for emissions reduction goals by target-setting future years and emissions quantities as it identifies where to prioritize emissions reductions.

A. ICLEI and ClearPath

To meet the goals and objectives of the project, the client initially proposed that we use the standardized framework for GHG inventories created by the Cities for Climate Protection (CCP) Campaign under the International Council for Local Environmental Initiatives (Defee, Minerva, et al., 2022). ICLEI is an international, non-governmental organization providing technical consulting to local governments to promote sustainable development. It was founded three decades ago after a group of mayors came together at a United Nations matting to discuss their role in reducing environmental pollution. Since then, ICLEI has helped over 600 local communities become more sustainable. Their CCP campaign "enlists cities to adopt policies and implement measures to achieve quantifiable reductions in local greenhouse gas emissions, improve air quality, and enhance urban livability and sustainability." Communities that participate in bold climate action benefit from financial savings through reduced utility and fuel costs, improvement of local air quality, and enhanced economic development (Cusick, Julia, et al., 2017).

The client team expressed that their interest in working with graduate students is largely due to Greenville's lack of any environment- or sustainability-focused staff positions within the city government to facilitate this type of project. Despite not having a designated sustainability professional, Greenville is looking forward to utilizing the results of our project to set targets and implement action plans to reduce their GHG emissions for years to come. Because they do not have any staff exclusively devoted to sustainability, we are hoping to be able to present them with a tool that will more easily allow them to generate reports to compare to the 2019 baseline we create so that they may continue to pursue their sustainability goals and track their progress.

A membership to ICLEI gives local governments access to a plethora of tools, trainings, and a designated technical advisor for membership support. ICLEI's industry-standard emissions management tool, ClearPath, is a top-tier online platform for completing GHG inventories and streamlining emissions management. The tool allows cities to monitor on a community-wide or government-operations scale. As per the city of Greenville's request, we will be conducting a baseline GHG emissions inventory at the government-operations scale and will be creating an independent Community Action Plan to encourage community-wide sustainability efforts. At the selected scale, ClearPath will track direct and indirect emissions from categories such as energy, transportation, waste, consumption, and forests and trees. Once the baseline emissions data is put in ClearPath, the tool can forecast future emissions by producing business-as-usual scenarios as well as emissions forecasts based off specific, modeled GHG emissions reduction actions. Lastly, the tool allows cities to monitor progress by tracking the effective energy savings of specific implemented actions and determine the emissions reductions achieved year-on-year.

While the inventory module operates similarly to the EPA's free emissions inventory calculator, the program's greater value lies in its forecasting and planning tools which can create visually attractive and concise tables and graphs at great ease. The instantaneously created visuals provide time-savings and the consistency of their format allows them to be easily compared across years or across other cities.

B. Previous Greenville Climate and Sustainability Projects

Under the office of City Manager, Barbara Lipscomb, the City of Greenville created a Sustainability Plan in 2013 that highlighted past or in-progress efforts to increase sustainability in municipal operations across the Fleet Maintenance, Building and Grounds, Transit, and Sanitation Divisions. The Excel document also detailed the Schneider Energy Performance Contract, a comprehensive energy savings project, in which a contractor specializing in LED retrofits, upgraded HVAC mechanical equipment, and supplemented solar thermal into some hot water systems. The project, which was contracted in 2012, had expected savings by 2019 of $1 million.

Also in 2013, the city released "Green Works", a document highlighting the sustainability efforts implemented across municipal operations. The report, which gives acknowledgement to the Environmental Advisory Commission, intended to be a baseline of information across five major categories: buildings, transportation, urban forestry, solid waste, and public engagement. It details the vision for sustainability by recognizing that, in 2009, Greenville was designated as a "Cool City", a city committed to taking action to increase energy management, waste reduction, clean fleets and fuel, and education and outreach regarding these actions to reduce GHG emissions and promote climate protection. The Green Works Report also describes the LED retrofit project for both city streetlights and traffic signals, and it details the city's electric vehicle purchasing and infrastructure development.

II. Methodology

Our research began with a literature review of baseline greenhouse gas emissions inventories, calculation methods, and reduction plans. We then benchmarked Greenville's per capita emissions and sustainability efforts against other North Carolina municipalities. The boundary of our inventory included the municipal operations of Greenville, North Carolina across five sectors: Buildings, Vehicle Fleet, Streetlights, Wastewater, and Municipal Waste.

We coordinated a site visit to Greenville to meet with the primary clients, tour facilities, and meet other city employees with access to pertinent data necessary for the inventory. Prior to the meeting, we emailed this list of city employees all the possible data calculators identified in ClearPath which spanned the following categories: Buildings & Facilities, Streetlights & Traffic Signals, Vehicle Fleet, Employee Commute, Electric Power Production, Solid Waste Facilities, Water & Wastewater Treatment Facilities, and Process & Fugitive Emissions.

After the site visit, the city employees sent us raw data that we requested to fill out ClearPath's available calculators. Because the raw data came from many different sources, we decided it was crucial for replicability to organize the raw data measurements into their own sheets within a single Excel document that can be easily shared with city employees in the future. We noted who from the City of Greenville provided each data point, along with their department, contact information, and where in our Master copy the data is located. This way, any individual conducting future greenhouse gas emissions inventories will be able to easily determine who they must contact for data as well as what department and data to expect in order to conduct subsequent inventories. This is to ensure replicability, a primary objective for city employees. The figure above displays the sheet, "Data Sources COG," where this information is housed. Each of the additional sheets house data from the City of Greenville or Greenville Utilities that we have edited into the format or units used by ICLEI's ClearPath tool. We also kept all the raw data sent to us separately for future reference.

We input and organized the baseline FY2019 raw data from city employees into a single Excel document, with individual sheets for each ClearPath emissions calculator. Once all data was consolidated, we converted measurements into the appropriate units used in ClearPath, if applicable, for aggregation. Then we input the data into the applicable emissions calculator in ClearPath. To analyze the results, we manipulated the data into graphs and charts that illustrate which sectors and specific indicators have the largest footprint for the city.

Lastly, we used the Forecasting portion of the tool to create business-as-usual scenarios to use for comparison against scenarios with various emissions reduction measures implemented. This allowed us to analyze and determine which actions provided the most emissions reduction potential for the city. ClearPath does not consider the cost of emissions reduction measures, so the economic implications of these strategies were not analyzed within the scope of this project.

A. Baseline Results

To simplify and avoid double counting operational activities, GHG emissions are broken down into three categories: Scope 1, Scope 2, and Scope 3. The scopes framework allows inventories to differentiate direct emissions occurring physically within a city (Scope 1) from indirect emissions occurring outside a city (Scope 3) and from indirect emissions from electricity usage, which may or may not cross city boundaries (Scope 2). These emissions are measured in metric tons of carbon dioxide equivalent (MT CO_2e), which quantifies the emissions' global warming potential in relation to carbon dioxide so that their values are directly comparable.

The following (Table 1 and Figure 1) convey the comprehensive results for the baseline GHG emissions inventory of the City of Greenville's municipal operations from fiscal year 2019, comprised of both direct and indirect emissions sources.

Table 1. Inventory Results for Municipal Operations by Scope of GHG Emissions (MT)

Scope	CO_2e (MT)
Scope 1	6,275
Scope 2	4,096
Scope 3	1,578
Total Emissions	11,949
Removal by Tree Cover	-695
Sum of Footprint	11,254

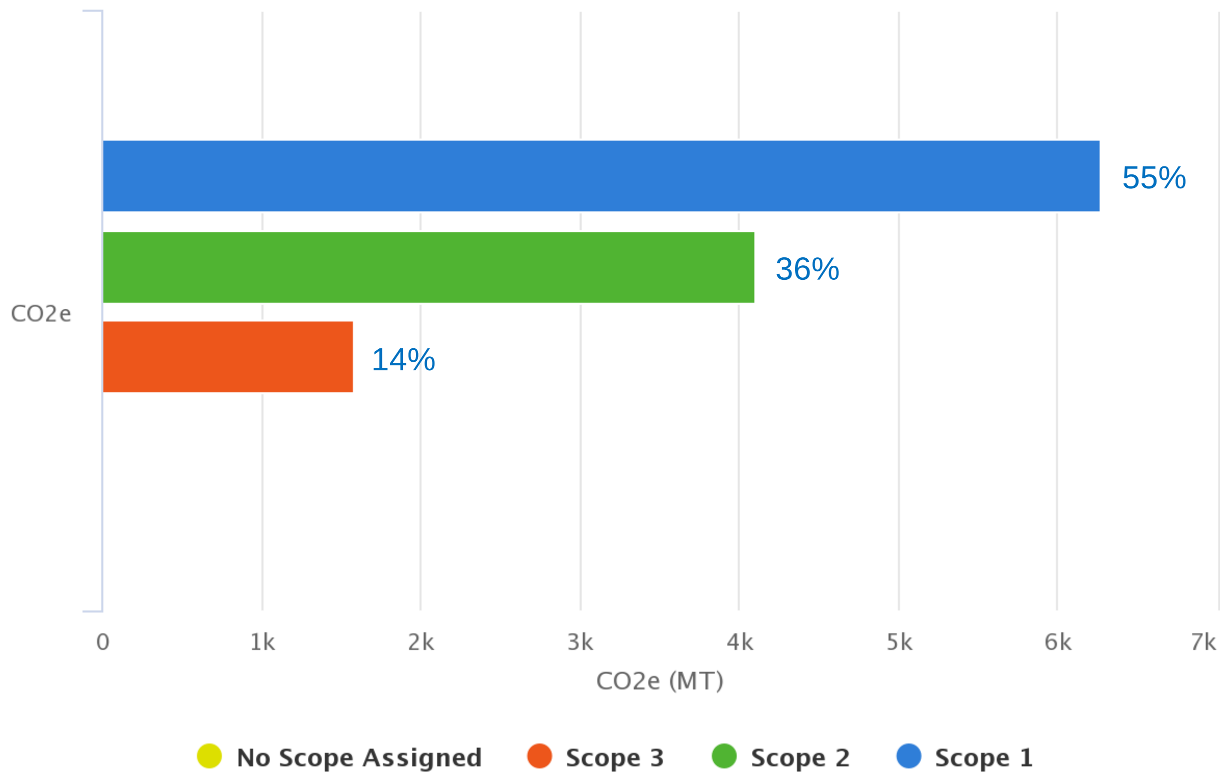


Figure 1. Inventory Results by Contribution of GHG Emissions Scope (MT CO_2e and % Contribution of Scopes)

The baseline inventory for FY2019 resulted in 11,949 metric tons of CO_2e emissions from Greenville's municipal operations (Table 1). However, 695 metric tons of CO_2e, or 5% of the total footprint was removed due to the tree canopy within the city limits. Therefore, the inventory resulted in a total 11,254 metric tons of CO_2 equivalent GHG emissions. Figure 1 indicates that a majority of emissions come from Scope 1, or Greenville's direct operations. Roughly one third of the city governments' emissions come from Scope 2, or Greenville's indirect emissions from purchased electricity. Lastly, the smallest contribution to the footprint of municipal operations comes from Scope 3, or indirect emissions from activities within Greenville's value chain. This represents the Scope 3 that we received data for and for which the city of Greenville if financially or operationally responsible.

The following is a comprehensive inventory of the City of Greenville's baseline FY19 GHG emissions inventory, comprised of the following six sectors of municipal operations: Vehicle Fleet, Buildings and Facilities, Streetlights and Traffic Signals, Employee Commute, Solid Waste Facilities, Process and Fugitive Emissions.

Buildings and Facilities data encapsulates the GHGs emitted by any process used to run municipal buildings, primarily the consumption of electricity and natural gas. Emissions from Streetlights and Traffic Signals are measured purely by the electricity they consume. Vehicle fleet, in this case, includes both the city's transit fleet and any vehicles or tools that run on combustion engines (lawnmowers, leaf blowers, etc). These emissions come primarily from the burning of various fossil fuels, though any emissions associated with the electricity used to run EVs should also be included in this category. Since Greenville does not run its own municipal waste facility but sends its waste to a landfill run by another entity, the only solid waste data considered in this analysis is the emissions from the waste discarded by municipal operations and facilities. Employee commute data is intended to include the emissions created by all municipal employees getting to work, regardless of their method of transportation, though this data is primarily estimated in our analysis. Finally, Process and Fugitive emissions is a category meant to capture all other possible sources of GHGs produced by municipal operations, though these primarily fall into the category of Scope 3 GHG emissions, and very few were available to us for this analysis.

Table 2. FY19 Inventory Results by Emissions Scope and Sector of Municipal Operations (MT)

Scope	Sector	CO_2e (MT)
Scope 1	Buildings & Facilities	582
Scope 1	Vehicle Fleet	5,675
Scope 1	Process & Fugitive Emissions	16
Scope 2	Buildings & Facilities	2,061
Scope 2	Streetlights & Traffic Signals	2,035
Scope 3	Employee Commute	1,342
Scope 3	Solid Waste Facilities	236
No Scope Assigned	Buildings & Facilities	-695

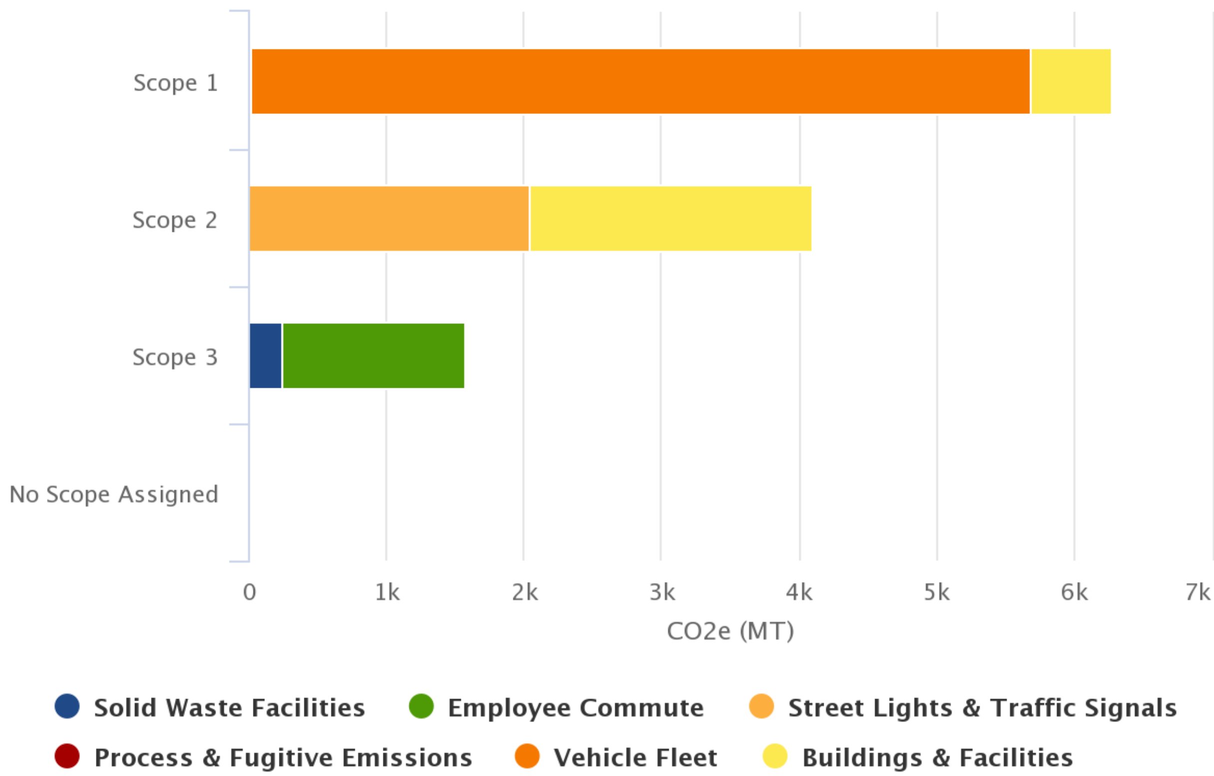


Figure 2. FY19 Inventory Results by Emissions Scope and Sector Contribution (MT)

Figure 2 illustrates that the Vehicle Fleet sector is the largest contributor to Greenville's direct emissions. Other sectors with large contributions include Buildings & Facilities (Scope 1 and 2) and Streetlights & Traffic Signals (Scope 2). These indirect emissions are coming from the purchase and use of electricity to power and operate these activities. Greenville's Scope 3 indirect emissions represent the Employee Commute and Solid Waste sectors.

Table 3. FY19 Inventory Contribution by Sector (MT)

Sector	CO_2e (MT)
Vehicle Fleet	5,675
Buildings & Facilities **695 MT CO_2e was removed by tree canopy*	1,948
Streetlights & Traffic Signals	2,035
Employee Commute	1,342
Solid Waste Facilities	236
Process & Fugitive Emissions	16

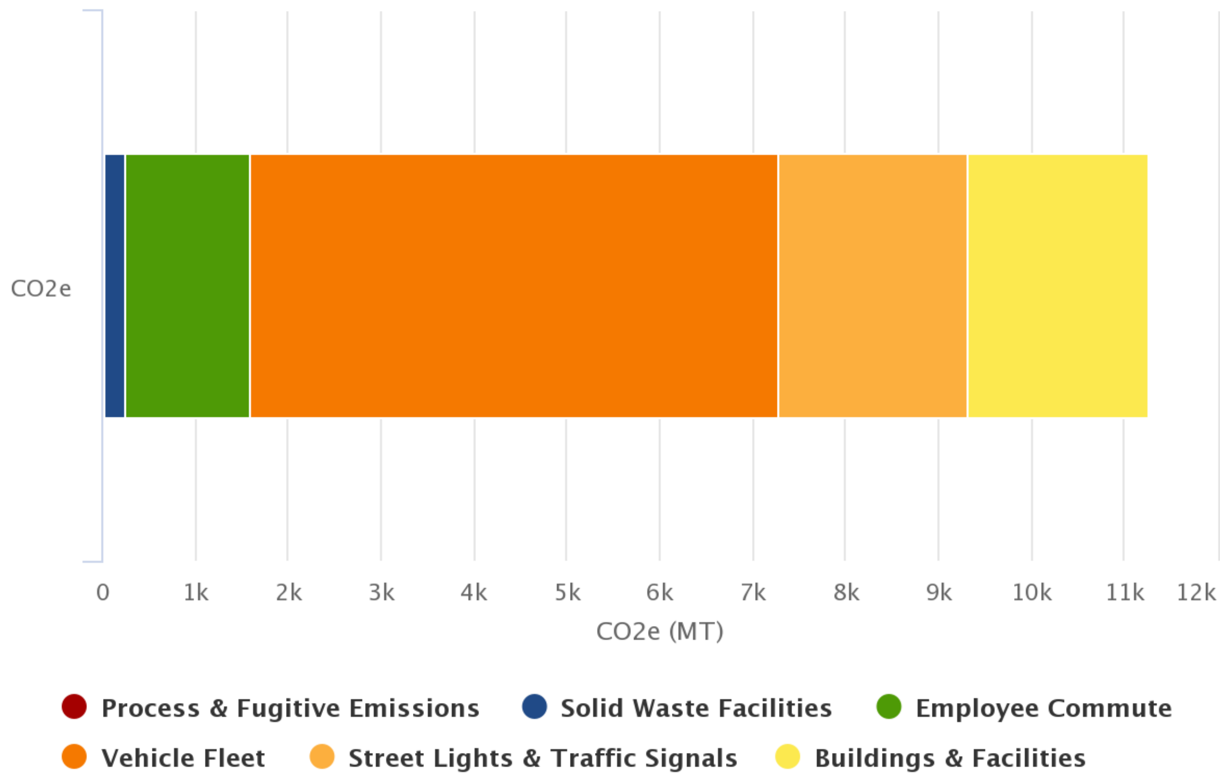
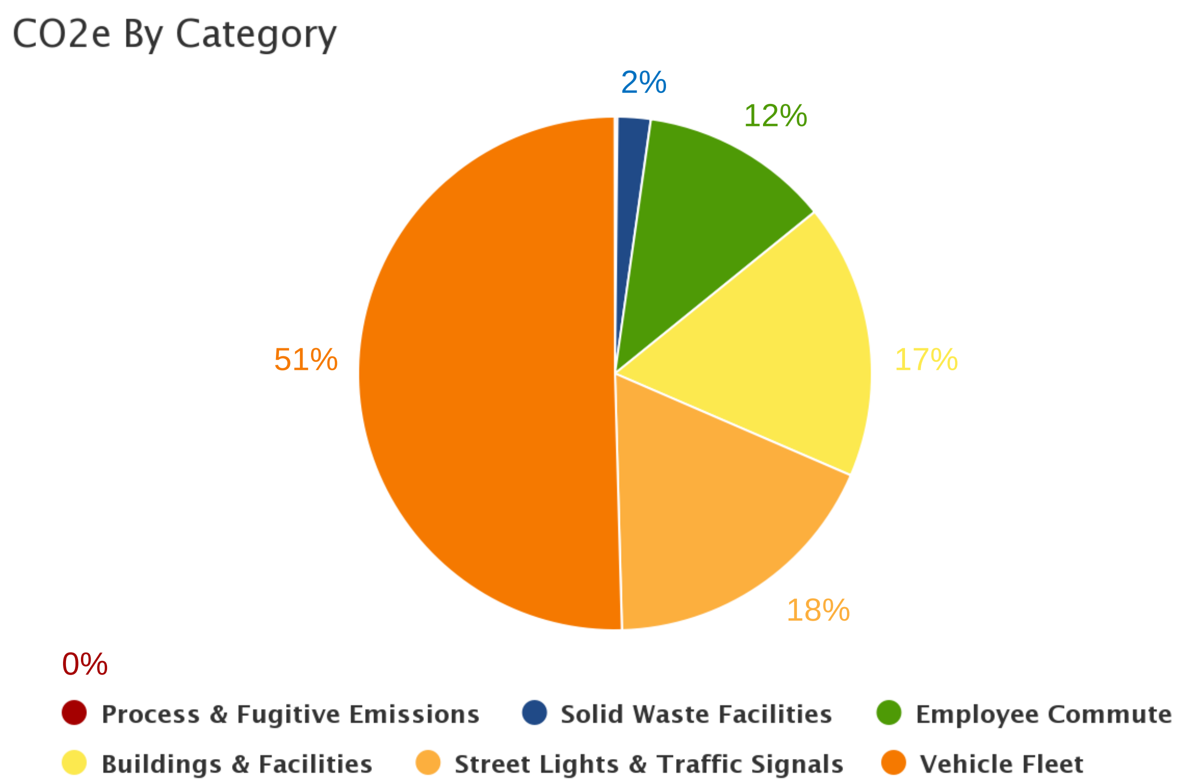


Figure 3.1. FY19 Inventory Contribution by Sector (MT)

Figure 3.1 illustrates the measurement of CO_2e emissions of each of the six sectors of municipal operations, but wastewater is not represented. This is because their stormwater system is passive, and the municipal government does not control the city's wastewater treatment facility. The Process and Fugitive Emissions sector appears not be represented in Figure 3.1 because it is negligible (at 16 metric tons of CO_2e emissions) in comparison to the other sectors. Greenville's Vehicle Fleet is the largest contribution to its total emissions inventory from municipal operations at 5,675 metric tons of CO_2e. Streetlights and Traffic Signals appears to be the second largest contributing sector at 2,035 metric tons of CO_2e. However, that is because ClearPath reports the contribution of the Buildings and Facilities sector as 1,948 metric tons CO_2e (the total footprint after considering the sequestration of 695 metric tons of CO_2e by Greenville's tree cover), instead of its measured total emissions from the inventory of 2,643 metric tons of CO_2e.



**695 MT CO_2e removed from Buildings & Facilities by tree canopy*

Figure 3.2. FY19 Inventory Contribution by Sector (%)

Figure 3.2 illustrates the percent contribution of each of the six sectors in Greenville's baseline GHG emissions inventory. This figure is important to illustrate and consider since this chart will be comparable to the results for cumulative emissions of other cities using ClearPath as well as internally comparable to Greenville's results for future inventories. It includes the emissions reductions from the city's tree canopy, which are taken out of the Buildings and Facilities sector. However, because of this, it does not give an accurate representation of the total emissions contributed by each sector since it misrepresents the total CO_2e emitted by the Buildings and Facilities sector.

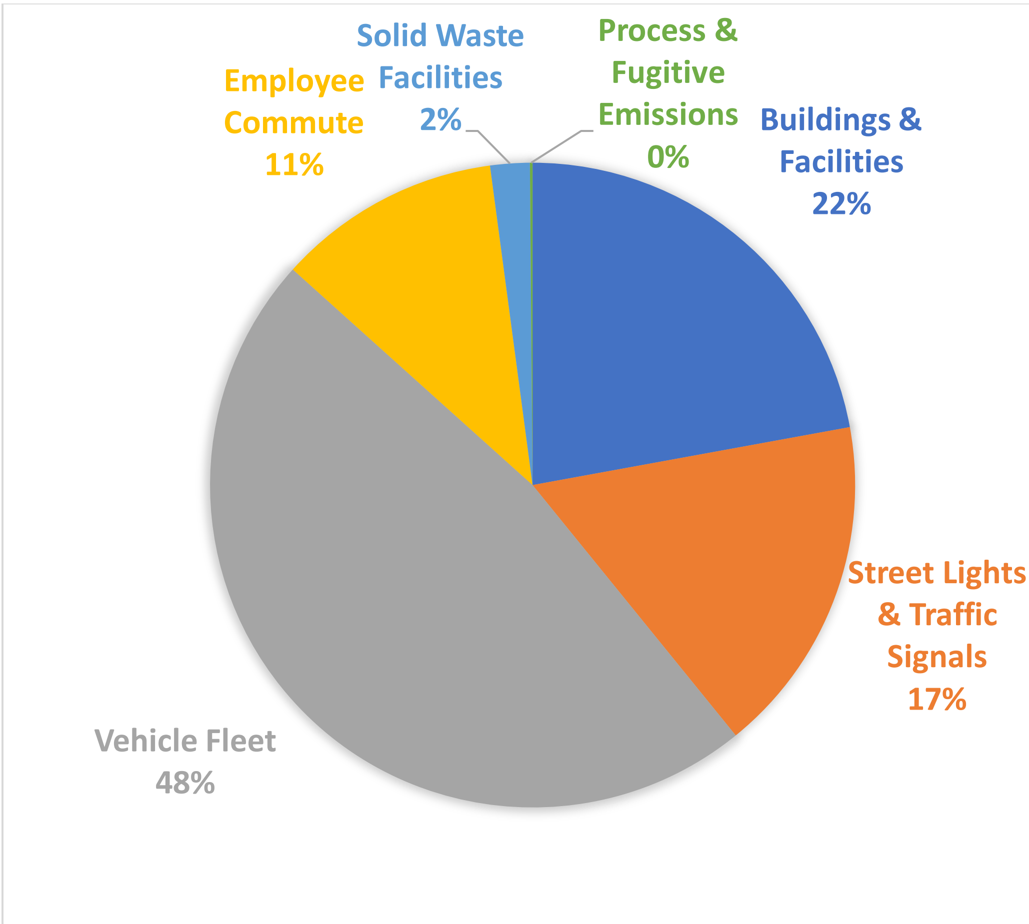


Figure 3.3. FY19 Inventory Contribution by Sector, Total Emissions (%)

For this reason, we created a secondary chart (Figure 3.3) that uses the total emissions value for Buildings and Facilities prior to the reduction by tree canopy. When comparing Figures 3.2 and 3.3, it is evident that considering the reduction by tree canopy skewed the resulting sector contributions. Most notably, Streetlights and Traffic Signals and Buildings and Facilities went from 18% and 17% contribution respectively (Figure 3.2) to 17% and 22% contribution respectively (Figure 3.3). For this reason, the city should consider whether to include the tree canopy in sector analyses in future inventories, as it can skew the emissions from Buildings and Facilities and misrepresent which sectors are the leading contributors. This carbon removal is important and relevant to include in the final measurement of the city's GHG footprint, but because it obfuscates data about the true footprint of municipal buildings, sector comparisons should be made that do not include this data.

The client should also consider whether a more granular breakdown for future inventories would be useful in planning where to allocates resources for implementing emissions reduction measures. For example, emissions calculations could be broken down by department, by building, by month, or, in the case of streetlights, even by the type and wattage of bulb. However, given the need to maintain replicability and keeping time constraints in mind, this kind of detailed analysis falls outside the scope of this project.

B. Emissions Analysis: Contribution by Sector and ClearPath Record

1. Vehicle Fleet

Table 4.1. Numeric Inventory Records for Vehicle Fleet

Vehicle Fleet	CO_2e (MT)
Fleet (Diesel)	2,974
Fleet (Unleaded Gasoline)	2,701

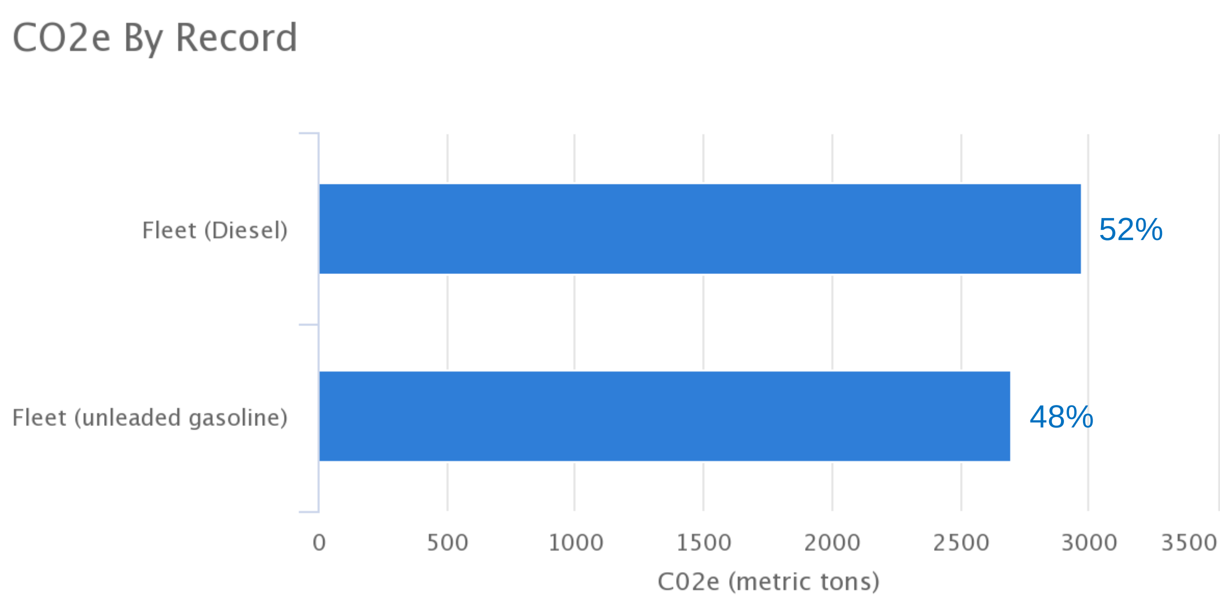


Figure 4. Graphic Inventory Records for Vehicle Fleet

Figure 3.3 clearly illustrates that Vehicle Fleet is the largest contributor to Greenville's emissions. These results were surprising considering it is most common for Buildings and Facilities to have the largest contribution on a city's GHG emissions inventory. Some initial hypotheses for these results are that Greenville has a larger per-capita fleet or that the footprint of their buildings decreased immensely with their 2013 LED retrofit project, both of which result in the Vehicle Fleet sector producing more emissions than Buildings and Facilities. The city's carbon footprint from their vehicle fleet results in 5,675 metric tons of CO_2e, but 52% of these emissions are coming from diesel usage (Figure 4). If the fleet data we received is accurate, the city is using a dirty fuel mix that contributes significantly to the city's footprint. To make the most well informed and valuable recommendations, it was crucial to consider the vehicle fleet in further detail.

Table 4.2. Fleet Makeup

Fleet Information	Units	Annual Fuel Use	Annual Miles Traveled
Passenger Vehicles (Unleaded Gasoline)	201	307,197	1,493,869
Trucks (Diesel)	323	291,235	1,336,763

Greenville's passenger vehicles, which consist of cars and motorcycles, use unleaded gasoline. The city's trucks, which consist of light, medium, and heavy trucks, use diesel fuel. Greenville's fleet has significantly more vehicles that use diesel fuel compared to unleaded gasoline use (Table 4.2), but the city's gas-fueled vehicles use more gallons of fuel and travel more miles annually than the diesel-fueled trucks (Table 4.2). While their passenger vehicles are driven more than the trucks, Greenville's fleet emissions are more heavily a result of diesel use (Figure 4.1).

2. Buildings & Facilities

Table 5. Numeric Inventory Records for Buildings and Facilities

Buildings & Facilities	CO_2e (MT)
FY19 Grid Electricity	1,958
FY19 Grid Emissions	104
CO_2 Removal from Tree Cover	-696
FY19 Natural Gas from GUC	583

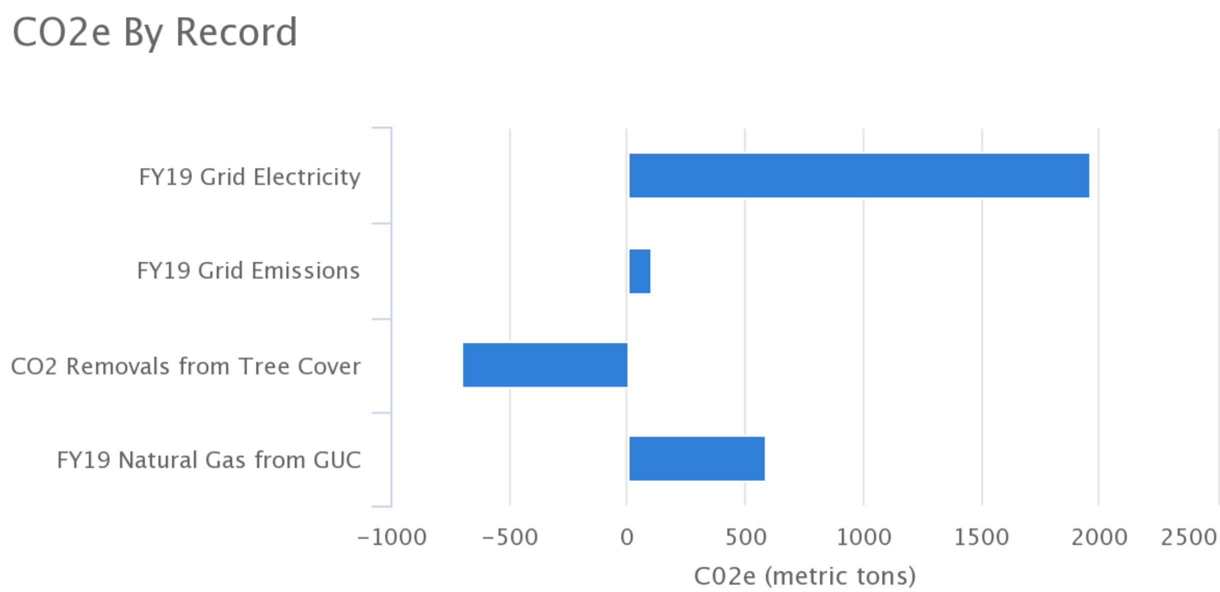


Figure 5. Graphic Inventory Records for Buildings and Facilities

Greenville's buildings have a lower footprint than many peers with a total footprint of 1,948 metric tons of CO_2e (Table 3) and total emissions of 2,643 metric tons of CO_2e (Table 5). This is likely because the major sustainability initiative that the city took on was the previous building energy efficiency project. The comprehensive 2013 LED retrofit project was effective in reducing the energy intensity of municipal buildings. Along with investments in building efficiency improvements through more efficient lighting, the city also managed to reduce emissions from buildings through conservation of utilities by turning lights off when not in use.

3. Streetlights & Traffic Signals

Table 6. Numeric Inventory Records for Streetlights & Traffic Signals

Streetlights & Traffic Signals	CO_2e (MT)
Streetlights FY19	1,933
FY19 Grid Emissions (Streetlights)	102

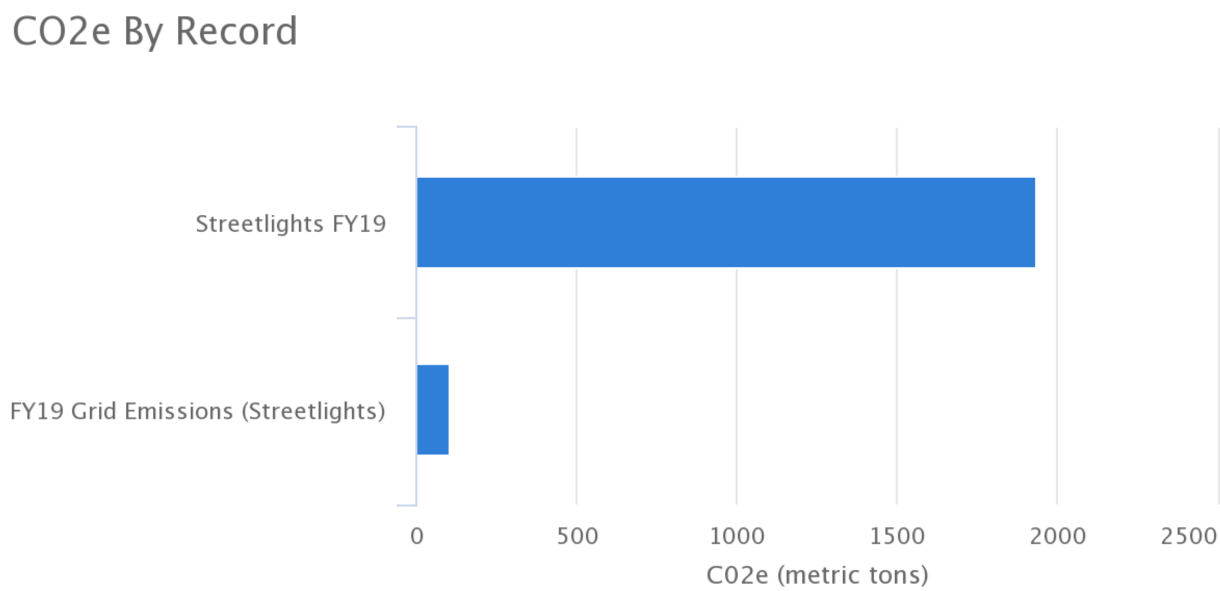


Figure 6. Graphic Inventory Records for Streetlights & Traffic Signals

The carbon footprint of Greenville's Streetlights and Traffic Signals Sector totals 2,035 metric tons of CO_2e (Table 6) which accounts for 17% of their baseline FY19 GHG emissions (Figure 3.3). The city maintains 125 traffic signals, all of which were previously converted to LEDs due to their more energy efficient consumption, improved color rendering index, and cumulative life cycle costs.

It is important to acknowledge that 2019 was the starting year of a four-year long project to convert all of Greenville's streetlights to LEDs. Because LED lights are more energy efficient and have a longer lifespan than the high-pressure sodium bulbs used, this project will result in reduced utility expenses as well as an annual decrease in emissions in the Streetlights and Traffic Signals sector through project completion in 2022. For this reason, future GHG emissions inventories for Greenville's municipal operations will show a smaller footprint for streetlights compared to the baseline results (Figure 6) and, therefore, a smaller contribution of the Streetlights and Traffic Signals sector to their total emissions.

4. Employee Commute

Table 7. Numeric Inventory Records for Employee Commute

Employee Commute	CO_2e (MT)
Emissions from Solo Drivers	1,279
Emissions from Carpool	64

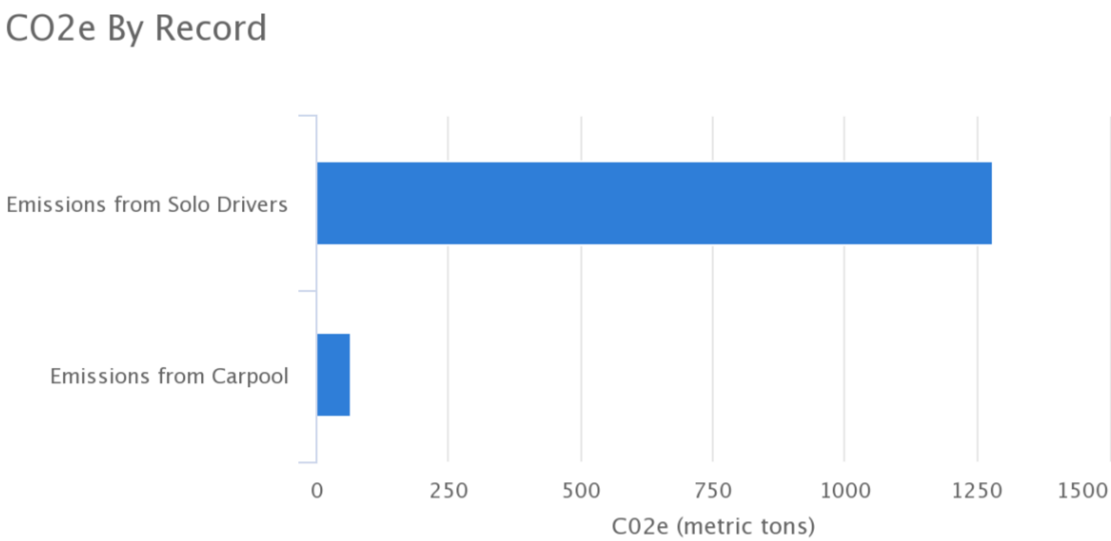


Figure 7. Graphic Inventory Records for Employee Commute

Emissions from employee commute totaled 1,342 metric tons of CO_2e (Table 3) and came from commuting records for both solo drivers and carpoolers (Figure 7). We made several assumptions for this sector due to a lack of data. Daily roundtrip commuting miles were provided by 61 employees from Greenville's Recreation and Parks department and extrapolated across total the number of full-time and part-time city employees which was 1,099. The assumption was that this roundtrip commute was made five days a week and then was extrapolated across the national average number of working days in a year. Lastly, we made an assumption for the proportion of carpoolers based on Pitt County averages ("Mean Commuting Time..."). In future inventories, data accuracy could be improved through completion of an employee commuting survey that identifies the daily roundtrip commuting miles, mode of transportation, and number of passengers in the vehicle.

5. Solid Waste Facilities

The City of Greenville's municipal government does not have operational or financial responsibility over solid waste facilities or landfills. The carbon footprint from this sector comes from one ClearPath record, which was the estimated annual waste generation calculated by the solid waste pickup from dumpsters at COG's owned or operated facilities across the city. The record resulted in 236 metric tons of CO_2e (Table 3), making the Solid Waste Facilities sector the second smallest contributor to Greenville's emissions (Figure 3.3).

6. Process & Fugitive Emissions

The carbon footprint for the Process and Fugitive Emissions sector came from one ClearPath record, water use, and was the smallest sector contributing to Greenville's GHG emissions inventory (Figure 3.3). Wastewater usage data from municipal operations was provided by Greenville Utility Commission and resulted in 16 metric tons of CO_2e (Table 3).

III. Forecasting Future Emissions

A. Reduction Goals

Before creating our forecasts, it was important to establish reduction targets to contextualize the significance of the projections. To ensure the most relevant targets, we used the statewide goals set forth by NC Executive Orders 80 (2018) and 246 (2022). Respectively, these mandate a statewide emissions reduction of 40% by 2025 and 50% by 2030, as compared to a 2005 baseline. Without a 2005 baseline for Greenville, we chose to extrapolate values from Asheville's 2007 inventory, given their similar populations and the fact that Asheville's wastewater treatment data can be easily disaggregated from municipal emissions. Using Asheville's 2007 data as a stand-in for 2005 emissions, and Asheville's 2015 data as a stand-in for 2019 emissions, we calculated a possible value for Greenville's 2005 GHG baseline as follows:

$$\frac{emissions_{Asheville\ 2005}}{emissions_{Asheville\ current}} = \frac{emissions_{Greenville\ 2005}}{emissions_{Greenville\ current}}$$

$$\frac{28{,}249\ mt\ CO_2e}{17{,}976\ mt\ CO_2e} = \frac{emissions_{Greenville\ 2005}}{11{,}254\ mt\ CO_2e}$$

$$emissions_{Greenville\ 2005} \approx 17{,}685\ mt\ CO_2e$$

Using this figure as the theoretical emissions baseline from 2005, Greenville would need to aim to reduce municipal emissions to 10,611 mt CO_2e by 2025 and 8,843 mt CO_2e by 2030 to meet the 40% and 50% reduction goals. These are represented by the red and green dotted lines, respectively, on the subsequent forecast graphs. They may initially appear to require only a relatively small decrease from the 2019 scenario—about 6 and 12 percent—but pose a significant hurdle for the city, as city management has already found most of the "low-hanging fruit" of GHG reduction tactics (that is, the projects which have the largest effect for the least possible expenditure of resources).

B. Business as Usual Scenario

To start, we chose to analyze two possible growth scenarios for Greenville—one in which the population grows at a similar rate to previous years, and a more aspirational, high-growth scenario. Based on the population growth between 2015 and 2019, we determined that the standard growth would be about 0.7%, while a more aspirational (but reasonable within the context of comparable cities) rate would vary between 2 to 3% growth over the next 10 years.

Generating the forecasts also required an estimate of the carbon intensity growth rate for vehicles and the electric grid. For vehicles, we used the Corporate Average Fuel Economy (CAFE) Standards laid out by the EPA, which stipulates a continuing decrease of 1.8% in vehicle carbon intensity. For grid electricity, we assumed that there will be no significant change in the carbon intensity of Greenville's grid for the next 10 years. We made this assumption because Greenville Utilities has maintained the state minimum portfolio of renewable energy sources, focusing instead on decreasing its carbon intensity by switching coal to natural gas and purchasing nuclear power ("Energy Mix", 2018). While natural gas is cleaner than coal, it is still emissions-intensive, and nuclear energy, though clean, has limited ability to expand its capacity. If Greenville's community power demands increase over the next 10 years, as we anticipate they will due to the interest of some business entities in moving to the area, Greenville Utility will likely rely on producing the extra demand through natural gas or coal, and will not be able to make significant strides towards reducing the emissions in its grid mix.

Using the aforementioned growth rates, we produced the following scenarios (Figure 8.1 and Figure 8.2) which estimate Greenville's possible emissions over the next decade under business-as-usual circumstances. The figures show the anticipated contribution of each sector to the city's overall emissions through 2030, as well as providing reference lines for the desired 2025 and 2030 reduction targets.

While we used these forecasts for our analysis, it is important to note that there are several limitations to the forecasting process. First, we have assumed for the purposes of this analysis that municipal operations will grow at a rate proportional to population growth. While this is the recommended methodology for longer time horizons (Yewdall), the fact that we are primarily considering only a 10-year period means that municipal operations may not see any growth or may grow at a rate much larger than the general population if new buildings are constructed.

Another limitation we faced within our forecasting is that our estimates of grid efficiency come from market research rather than from Greenville Utility Commission itself. GUC does not publicly share its plans for its renewable energy portfolio or whether it has net-zero aspirations for the foreseeable future. Most of its “Clean Future” plans focus on increasing natural gas usage as a lower-emission alternative to coal, gasoline, and diesel fuel (“Clean Future”, 2022). Though we feel fairly confident in our predictions for the grid mix given the available information and the lack of any public commitment to increasing its renewable energy portfolio, the lack of specific information from the utility decreases the precision of the forecasts.

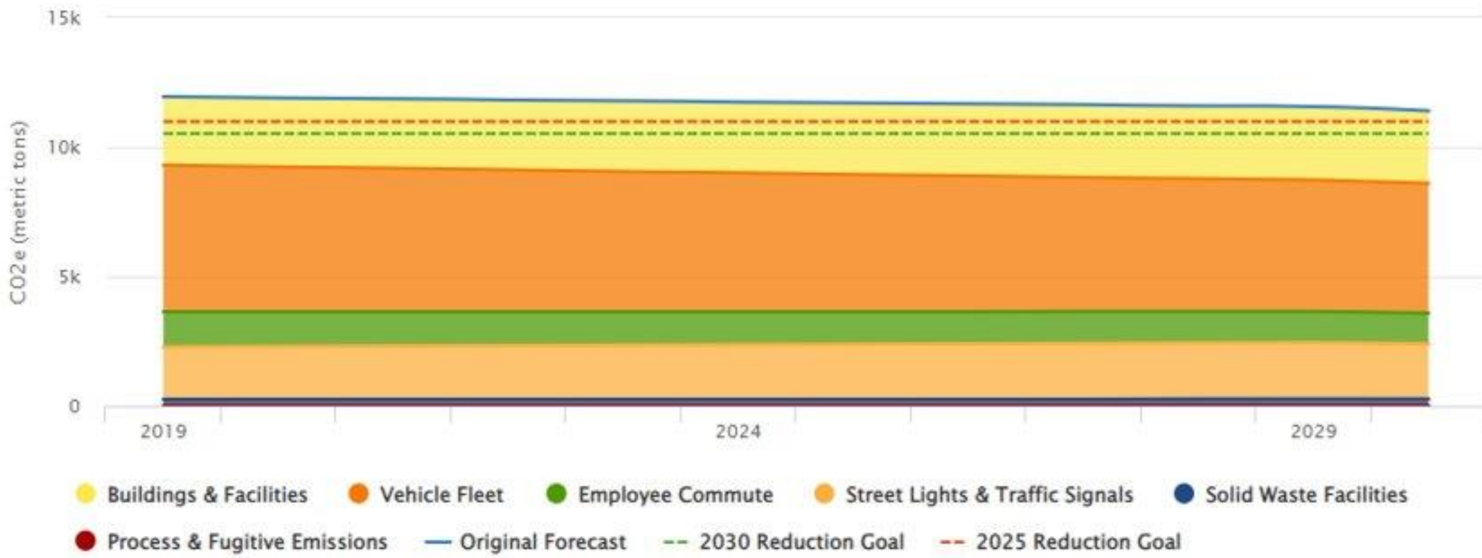


Figure 8.1. CO_2e Forecast with Standard Population Growth

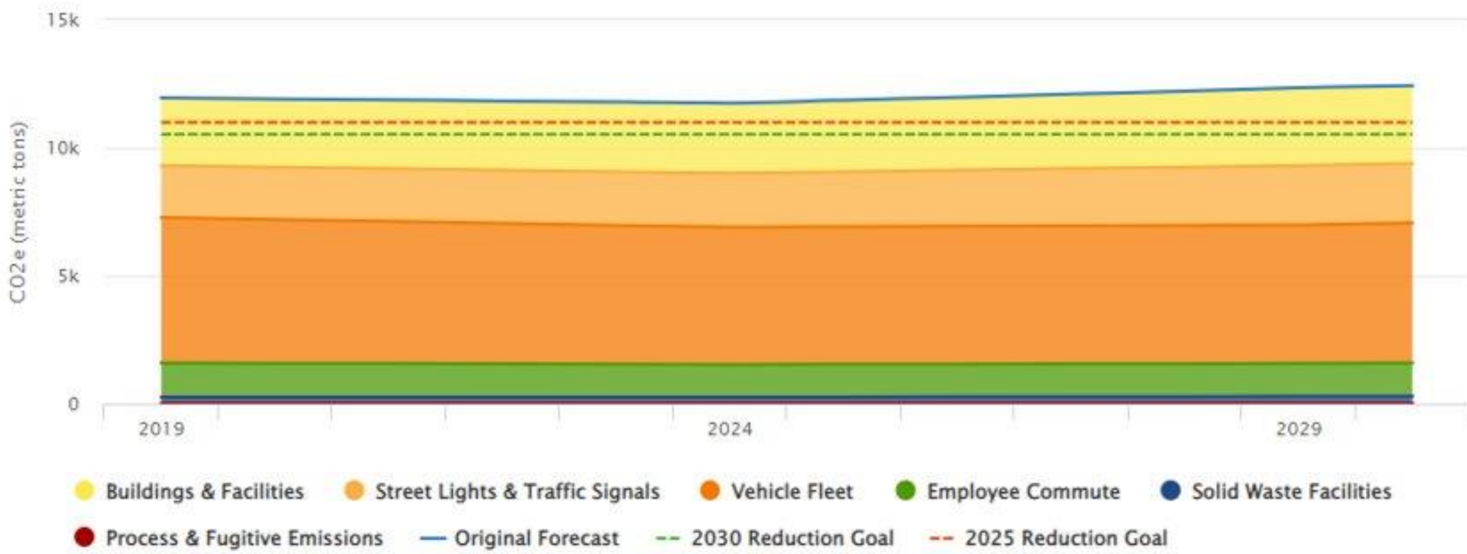


Figure 8.2. CO_2e Forecast with High Population Growth

C. Emissions Reduction Measures

To generate potential reduction scenarios, we identified five reduction techniques for which ClearPath could model future emissions, listed in order of their likely feasibility:

1. Increase the rigor of vehicle fleet maintenance
2. Convert 100,000 annual VMT from diesel fuel to compressed natural gas (CNG)
3. Convert 10% annual VMT from diesel fuel to electricity
4. Move 100 employees to full-time telecommute
5. Convert all gasoline used to ethanol

As a note, we are not recommending that Greenville actually pursue all of these actions in 2022, as many of them would require economic consideration and infrastructure building to accomplish. We also acknowledge that some of these would be difficult, if not impossible, to accomplish—for example, changing 100 full-time employees to full-time telecommuting is incredibly ambitious given the nature of most municipal jobs.

For the purposes of creating the starkest possible comparison to the baseline, we ran the forecast as if all 5 of these measures were to be implemented fully by the end of 2022. While this is not a realistic scenario, it allows for visualization of the maximum possible impact these measures could have on Greenville's emissions over the next 10 years. The following graphs illustrate the anticipated effect on Greenville's emissions until 2030 if all these measures were successfully implemented by December 2022.

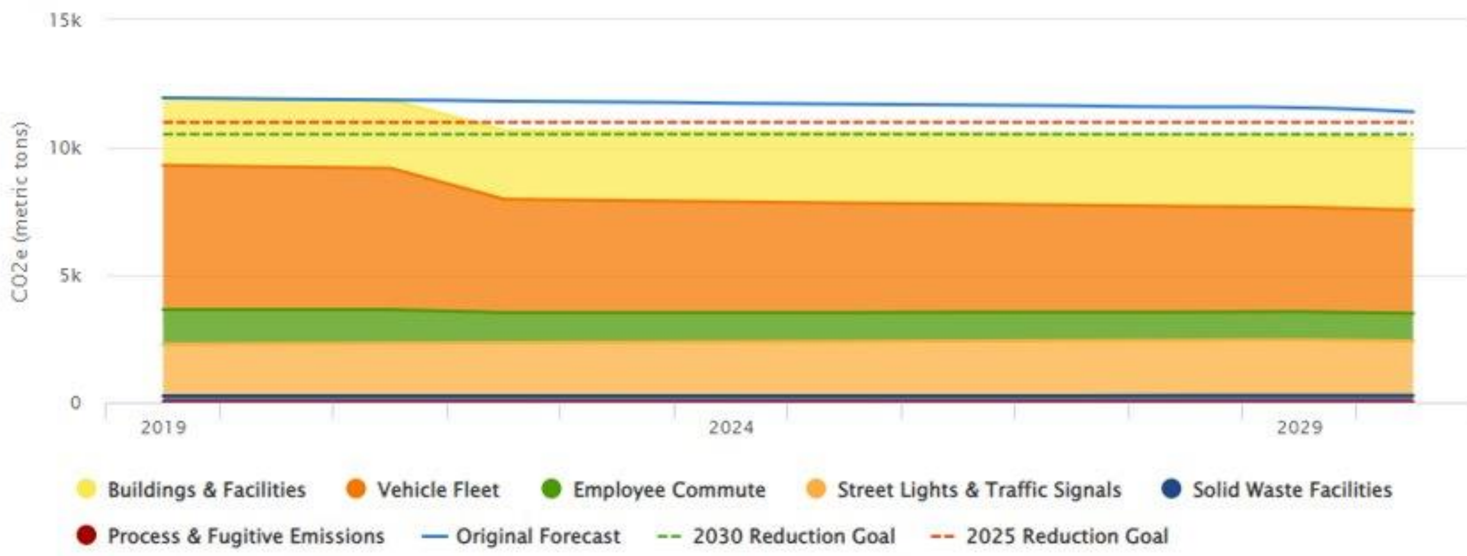


Figure 9.1. Standard Growth CO_2e Forecast with Reduction Measures

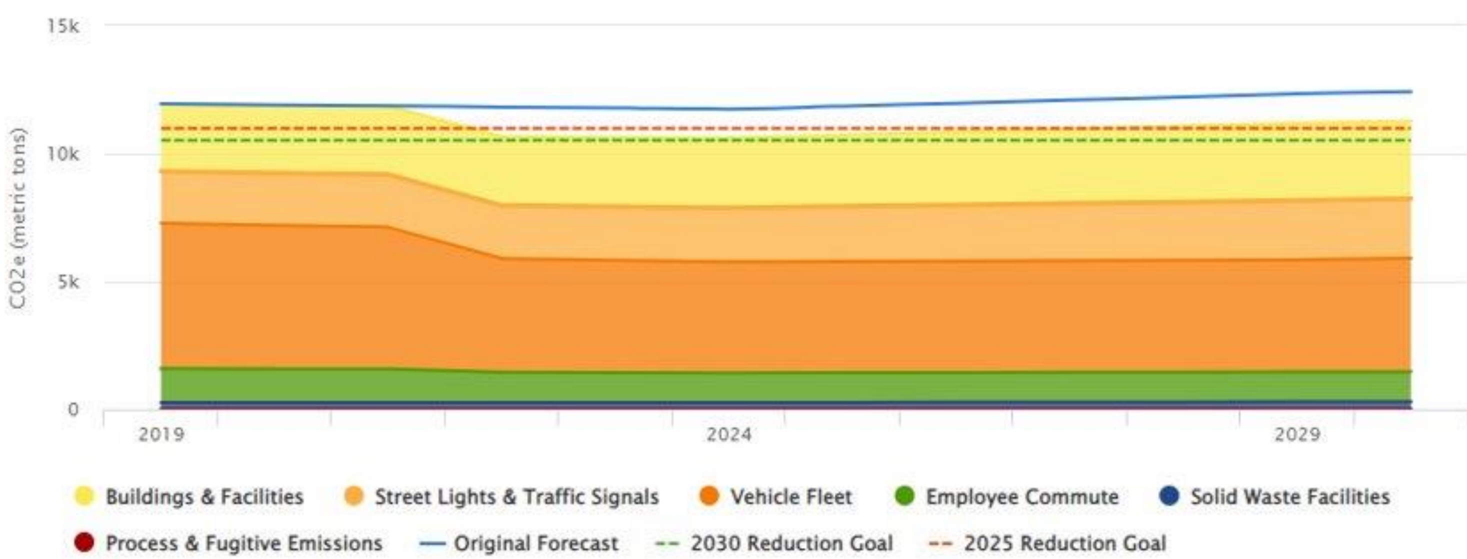


Figure 9.2. Standard Growth CO_2e Forecast with Reduction Measures

As is evident from these graphs, these measures could theoretically be sufficient to meet the state's reductions targets if population growth stays low, but if the city grows as rapidly as it hopes to, these measures will not be enough to meet the preliminary goal of a 40% reduction by 2025, let alone a 50% reduction. We show this to highlight the need for continuous sustainability efforts going forward, because Greenville will only be able to reliably reach its reduction targets if they continue to target new methods of reduction. Even if great progress is made, if sustainability efforts are contained to 2022, the city will miss its critical upcoming targets.

D. Economic Impacts

It should be noted that the above assessments do not incorporate the cost or economic benefit of the various measures to the city, as these were beyond the scope of this inquiry. However, it would be beneficial to Greenville, or any other municipality taking on a similar task, to consider an economic assessment of reduction measures as well. Greenville has already enacted one of the most economically beneficial GHG reduction measures in its conversion of all its electric lights to LED bulbs, which provide cost-savings through reduced energy use, decreased maintenance, and longer product lifespan. Certain vehicle replacements or building retrofits may yield similar economic benefits, but this analysis did not reveal any such major cost savings.

IV. Recommendations

After extensive consideration of the results, as well as input from various stakeholders connected with this report, we have developed a set of recommendations that we believe will yield the most significant emissions reductions for Greenville while minimizing costs to the city. Our recommendations, detailed below, fall primarily into three categories: focus immediate reduction efforts on improvements to the vehicle fleet; increase the accuracy and depth of information for reporting in order to more fully understand how improvements can be made; and establish an official sustainability office within city operations.

A. Vehicle Fleet

As previously shown, our analysis revealed that Greenville's vehicle fleet is the single greatest source of emissions from municipal sources, so it is also the area with the most room for improvement. The city has already implemented a no-idle policy for municipal vehicles, which has undoubtedly decreased fleet emissions from past years' levels. While many of the further reductions to fleet emissions will require replacement of current vehicles, one possible solution would be to increase the biofuel in the current gasoline mix being used for the municipal fleet. This is, of course, a delicate balance, as not every engine is built to tolerate a high concentration of ethanol. However, the information we were provided indicated a biofuel mix well below the national average which likely could be brought up to at least 15% ethanol without having any tangible effects on mechanical systems. Another solution that can be implemented immediately without purchasing new vehicles would be increased maintenance on the current fleet. Maintaining optimal tire pressure and using tires to the very end of their safe useful life are two examples of small changes that can increase the mileage of city vehicles, thereby decreasing emissions and fuel costs.

However, as time goes on, many of the larger reductions to fleet emissions will come from the replacement of current vehicles for more efficient alternatives. The most drastic way to see significant long-term emissions reductions would be to pursue fleet electrification, but this is a high-cost method requiring extensive infrastructure and planning which should not be undertaken without strategic forethought. If electrification is of interest, Greenville should pursue external grant funding for the process, like the ones currently being offered by the North Carolina Department of Environmental Quality as a part of the Volkswagen Settlement with the EPA, or those made available by the US Department of Transportation as part of the 2021 Infrastructure Investment and Jobs Act. Creating an electric fleet will still be costly to the city, but this funding can create a more reasonable cost structure that will allow the city to realize more immediate savings from the switch. Further, if Greenville does decide to electrify some of its fleet, it should focus its early efforts on the vehicles that emit most because of frequent use, like parking enforcement vehicles or transit buses.

Electrification is not the only vehicle replacement that may offer emissions reductions for the Greenville fleet. Another viable option would be to replace diesel engine vehicles with ones that run on compressed natural gas (CNG) when the old vehicles are retired. CNG runs cleaner than diesel and because the fuel is cleaner, CNG engines tend to last longer than diesel engines, leading to emissions reductions and cost-savings in both the short- and long-term. Compressed natural gas prices are also less volatile than gasoline prices, and as much as 40% lower. GUC already has CNG infrastructure in Greenville, so it may be feasible to use that pre-existing fueling infrastructure rather than the city constructing something new, offering further cost reductions ("Compressed Natural Gas", 2022).

One important element to note is that we do not recommend that Greenville replace functioning, efficient vehicles ahead of their scheduled retirement unless the vehicles will be put to continued use elsewhere (e.g., by being auctioned to citizens). While vehicle emissions are a large concern, the construction of a vehicle is a large part of its embodied carbon and sending a car to scrap before its useful life is over will ultimately increase Greenville's footprint, not diminish it.

B. Reporting

The baseline report generated for FY 2019, though useful for future comparison, does not offer significant insights into where to focus emissions reductions because the data was highly aggregated. In discussions with ICLEI representatives, we found that the more data can be broken down, the more functional these reports become. With more granular data, the program is better able to reveal anomalous emitters and problem areas. For example, some cities will create separate data sets for each individual vehicle in a fleet, which can reveal when vehicles are decreasing in efficiency or are in greatest need of replacement. This information can even provide support for grant applications or funding requests when the city is looking to upgrade a part of their fleet.

While tracking inputs at this level may be a goal for the city to pursue, we recommend that Greenville start by identifying useful categories within each sector and tracking inputs according to those categories. For example, buildings and facilities data may be broken down by building, or by function (firehouses, office buildings, etc). Currently, mileage within the transit fleet is tracked by vehicle type, but fuel usage is tracked only by fuel type. If vehicle type is deemed to be the most useful categorization of data, fuel usage should also be tracked by vehicle type. However, the city might also consider whether vehicle function or department might better serve their needs in understanding where emissions are originating. Further, it is critical that regardless of categorization, the city work to disaggregate transit fleet data from the rest of the vehicle fleet. By separating transit data, Greenville will be able to obtain a much more useful assessment of their fleet emissions and the best reduction strategies.

Beyond measurement and inputs, we recommend that the city use the remainder of their current ICLEI membership and access to ClearPath tools to develop inventories for the years 2005 and 2013 if possible. These will likely prove to be incomplete and based on assumption, as some data may be lost or inaccessible due to staff turnover or changing forms of bookkeeping, so the 2019 inventory should be maintained as the city's baseline for future comparisons. However, these two years will provide critical data for Greenville to understand its progress and set future goals. Most federal and state mandates regarding energy efficiency and emissions reductions, like NC's Executive Orders 80 and 246, set goals relative to an area's 2005 baseline. However, without an actual assessment of the city's 2005 emissions, Greenville must merely guess at its goals, which diminishes both the urgency to act and the feeling of accomplishment that should come with meeting those goals. We recommend the city conduct a 2013 inventory as well, though this is less critical than the 2005 inventory, as it would merely be a way to illustrate the emissions reductions from the city's full LED conversion of its facilities. Since Greenville has already embraced much of the low-hanging fruit of sustainability and will be seeing smaller reductions from its future initiatives, we think it would be beneficial for the city to see the effect this important initiative had on municipal energy use and emissions.

Finally, we recommend that Greenville work to expand the scope of their inventories and the emissions they measure. Several calculations and inputs were based on assumptions made by city engineers, on regional standards published by the EPA, or were extrapolated based on examples of similar cities in the region. Though this can give the city a good idea of the scope of their emissions, more reliable data will produce much more accurate and useful results. To do this, the city might consider conducting a waste audit of its municipal operations, surveying all employees about their commuting habits, and tracking the number of trees cut down by city employees each year. For example, both the completeness and accuracy of employee commuting activity data can be significantly improved by utilizing a survey that is easily navigable, has clearly articulated questions, and is distributed to all city employees. Further, city employees should look through the ClearPath tools provided to see if they might be able to collect data in some of the areas that were not covered by this assessment, like refrigerants, air travel, or catered food.

C. Sustainability Office

Engaging Duke to help establish this GHG inventory is a fantastic step in Greenville's sustainability journey. If the city hopes to continue the momentum from this project, it is important that they make sustainability a permanent fixture within city operations. City management has already expressed interest in hiring a sustainability manager for Greenville, which would be a highly effective way to operationalize sustainability within city government. However, we recommend that Greenville think beyond city limits when hiring a sustainability manager and consider establishing a sustainability manager (or office) that would advise a larger area—perhaps all of Pitt County. Durham's sustainability program is currently county-wide rather than just city-wide, which allows them to have a larger sphere of influence. This would be beneficial for both Greenville and the surrounding area, as the municipalities could share the cost of funding such an initiative in the same way that they share resources for the county-wide school district. If acting on behalf of a larger area, the sustainability officer could enact more systems-based solutions that would benefit Greenville in ways that hyper-local solutions could not. Furthermore, we encourage Greenville to engage with GUC about the possibility of their working with any sustainability manager hired by the city, as the utility's emissions have a direct impact on the city's emissions. By working with GUC to generate a cleaner mix of electricity, Greenville could see drastic reductions in its Scope 2 emissions and its community-wide footprint.

V. Benchmarking North Carolina Municipalities

For Greenville to understand where they lie in their sustainability journey and what progress must be made, it is helpful to look at the sustainability of other municipalities in Pitt County as well as other large cities in North Carolina. Greenville is the 11th most populous city in the state of North Carolina ("10 Largest Cities in North Carolina", 2022), but the largest municipality in its county by about 80,000 people. Pitt County includes ten municipaliteis in total: eight towns, one city (Greenville), and one village ("Municipalities"). North Carolina municipalities with publicly disclosed GHG emissions inventories are Greensboro (3rd largest in NC), Durham (4th), Winston-Salem (5th), Wilmington (8th), and Asheville (12th). Orange County, North Carolina also discloses GHG emissions data, and with a population of about 150,000 people collectively, it would be in the middle of the previous list ("Cities").

Greenville's primary competitors in the sustainability space will be the "leaders," cities with robust sustainability initiatives and well-developed climate adaptation and mitigation measures. For that reason, we chose to benchmark leading cities by analyze the development of their sustainability and GHG emissions reduction plans as well as their level of broader commitment to the sustainability of the city. To understand the sustainability landscape of North Carolina cities relative to Greenville, we chose four other cities to benchmark, three more populous cities and one less populous city than Greenville.

A. City of Charlotte

Charlotte is the largest city in North Carolina with a population of 925,290 residents ("10 Largest Cities in North Carolina", 2022). They amped up their sustainability efforts with the passage of the Sustainable and Resilient Charlotte by 2050 Resolution and the adoption of the Strategic Energy Action Plan, both unanimously passed by City Council in 2018 (City of Charlotte). The city has both 2030 and 2050 GHG emissions reduction targets and is a part of Bloomberg's American Cities Climate Challenge initiative. The city strives to have 100% of city fleet and facilities fueled by carbon neutral sources by 2030 and strives to be a low-carbon city at a community-wide level by 2050. The city government has a Sustainability Office with a Chief Officer and two Coordinators (City of Charlotte). Sustain Charlotte is a community-based NGO who has been advocating for smart-growth solutions to Charlotte's sustainability challenges since they published Charlotte 2030: A Sustainable Vision for Our Region in 2010 (Sustain Charlotte).

B. City of Raleigh

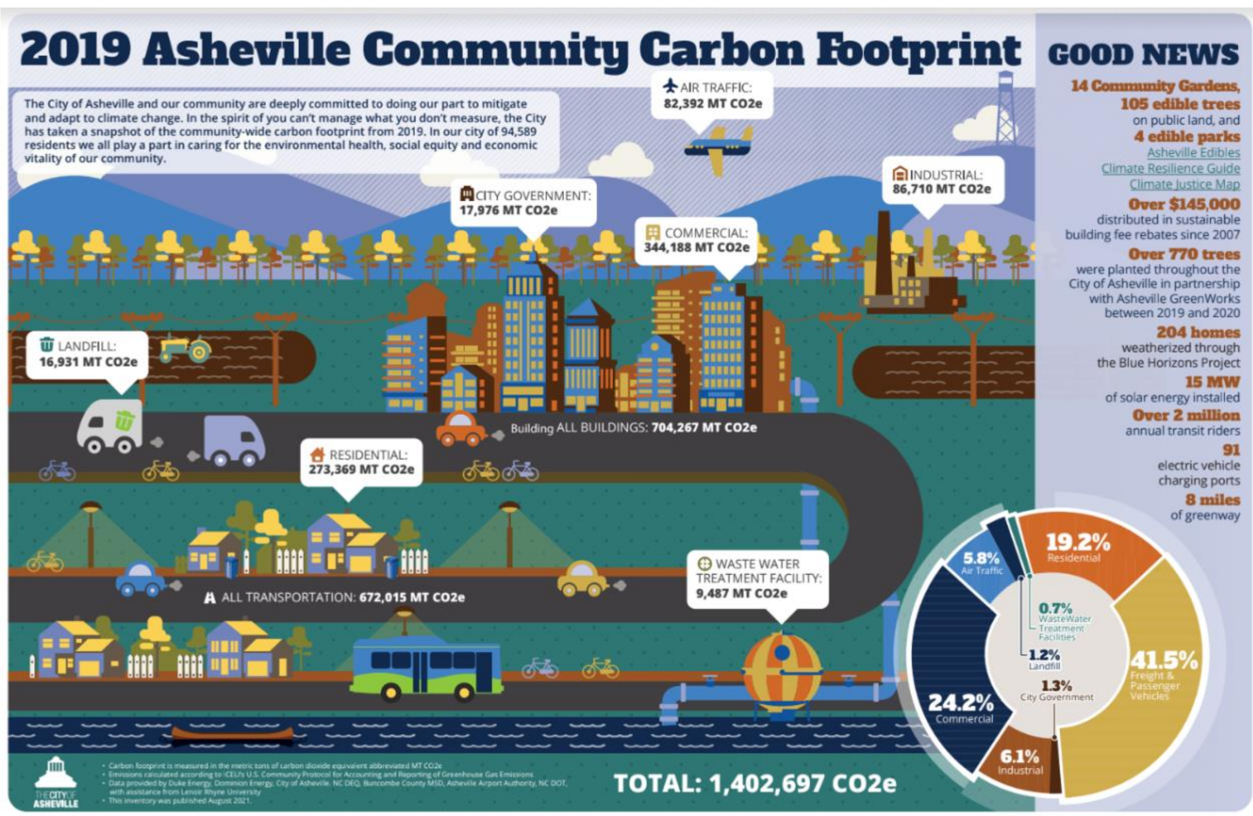
Raleigh is the second largest city in the state with a population of 488,334 ("10 Largest Cities in North Carolina", 2022). They created their baseline GHG emissions inventory at the government operations scale in 2010 ("Greenhouse Gas Emissions Reports"). In 2012, the city created a GHG emissions inventory at the community-wide scale for previous years 2007 and 2010. Both inventory scales were updated in 2016 using FY2014 data. Raleigh set a target to reduce their community wide GHG emissions by 80% by 2050 using the 2007 baseline inventory. The city also has a 2013 Sustainability Report and an Office of Sustainability, which currently consists of a Sustainability Manager and three other employees. They are in the process of hiring to expand their team. The City of Raleigh created a Community Climate Action Plan that focuses on building community resilience by engaging stakeholders and supporting climate equity.

C. City of Durham

The City of Durham has a population of 292,290 residents, making it the fourth most populous city in the state ("10 Largest Cities in North Carolina", 2022). Their baseline GHG emissions inventories at both the community-wide and municipal operations scales were created in 2009, and they were the first city in North Carolina to create a GHG emissions reduction plan. Durham has been tracking their emissions at both scales annually and have ambitious 2030 and 2050 targets. The Office of Sustainability (consisting of one Sustainability Manager) operates under Durham County, and it is within the Engineering and Environmental Services Division ("Durham, NC: Official Website").

D. City of Asheville

Asheville is the 12th most populous city in North Carolina with 93,590 (“10 Largest Cities in North Carolina”, 2022) and is the city most comparable in size to Greenville of those we reviewed. Their Office of Sustainability was created in 2008 and consists of a Sustainability Manager and a Sustainability Office Intern (Edwards and Miller, 2022). They were assisted by the city’s the Sustainable Advisory Committee for Energy and the Environment (9 members) in creating a Sustainability Management Plan in 2009. In 2018, the city created a Climate Resiliency Assessment that explores climate threats and community assets. In terms of municipal operations, Asheville has a 4% annual carbon reduction goal and a goal to source 100% renewable energy by 2030. The city created a community-scale carbon emissions footprint from 2019 data with an associated infographic below.



Source: City of Asheville – Sustainability

Figure 10. Asheville Community Carbon Footprint

This exemplary infographic stands out because it is readable and easily digestible by those without an environmental or sustainability background, particularly since it pertains to the entire community (Edwards and Miller, 2022). The vision and goals for the Office of Sustainability and the challenges they tackle are determined by the community and approved by the City Council.

E. Peer Benchmarking

Emissions per capita is a useful unit for comparing the emissions of a city because it accounts for differences in population size. We wanted to compare the emissions per capita of these cities to Greenville to understand where they lie in relation to their peers. This is helpful to consider since North Carolina has many state-wide emissions reduction and sustainability goals. For the four cities discussed previously, we took their most recent emissions at the municipal operations level and divided that by the city's population for that respective year.

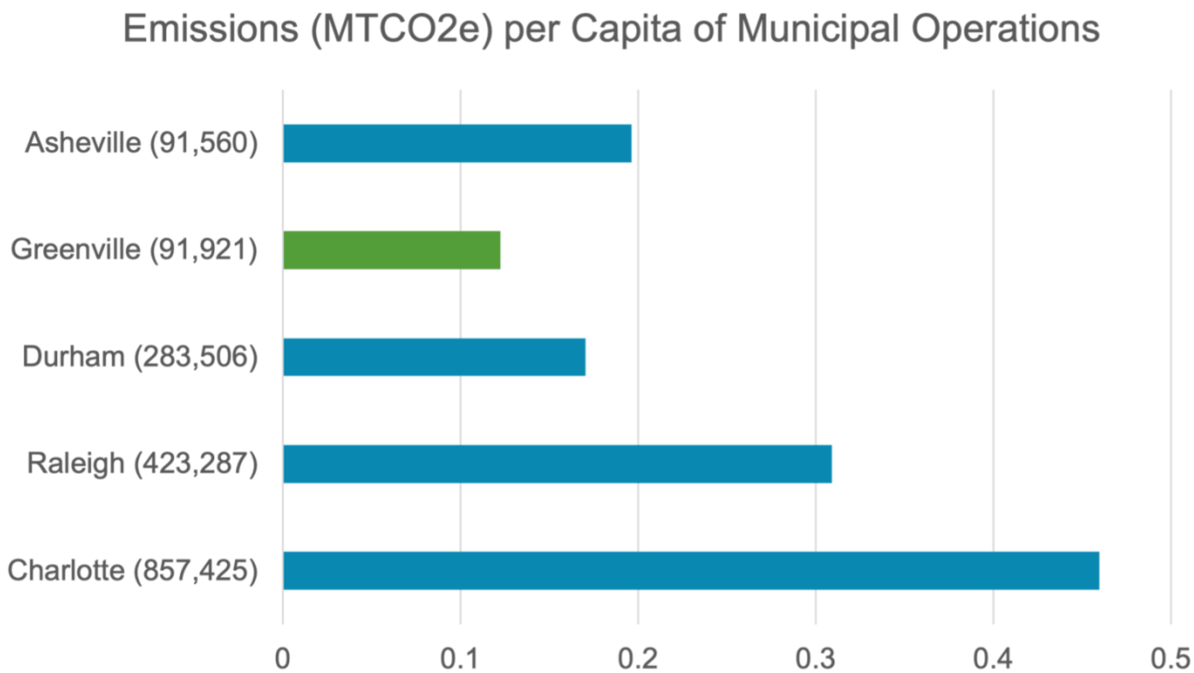


Figure 11. Emissions per Capita of North Carolina Municipalities

The results from Figure 11 indicate that Greenville has the lowest emissions per capita of the cities reviewed, which would indicate that Greenville's municipal government has the lowest operational footprint. However, it is more likely that the other cities have higher emissions per capita since their municipal governments are operationally responsible for landfills and wastewater treatment, both of which represent additional sectors contributing to total emissions. While these activities occur with the city of Greenville, the city is not operationally or financially responsible for them, so they are not included within the city's inventory, resulting in a lower emission per capita.

All four North Carolina cities reviewed track and report their community-wide emissions in addition to their emissions from municipal operations. We wanted to compare the emissions at both scales to get a picture of what contribution Greenville's emissions from municipal operations might have in relation to the emissions from the greater community.

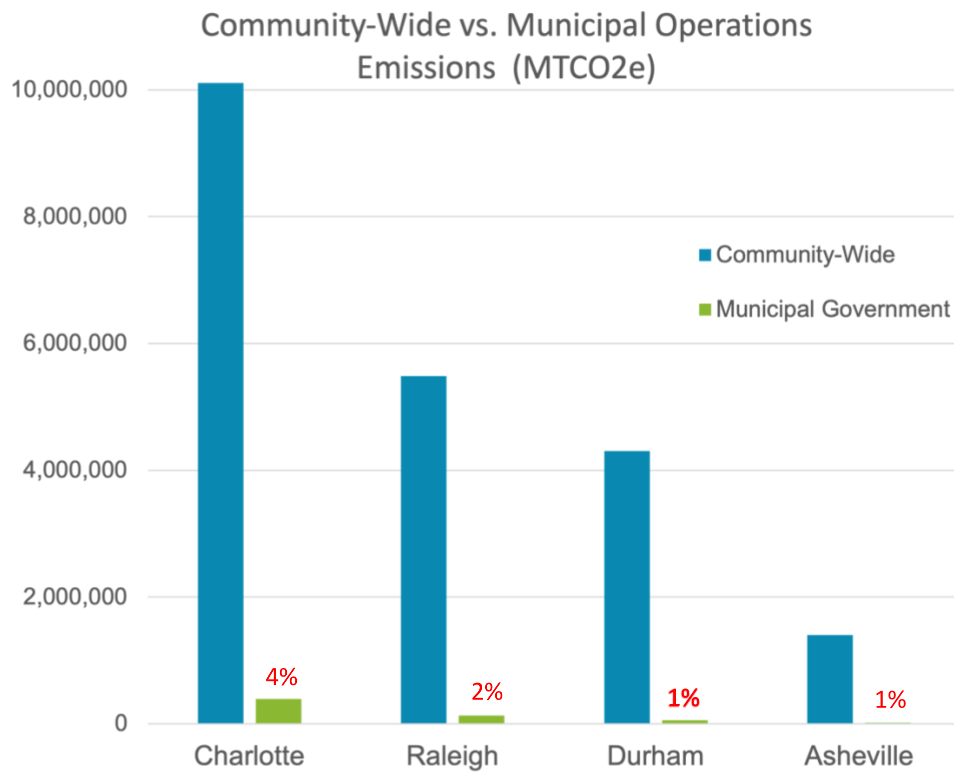


Figure 12. Contribution of Municipal Operations to Community-Wide Emissions

The results from Figure 12 illustrate that the emissions from municipal operations are only a minor contribution, 4% or less, of the community's emissions. Further, because Greenville's population lies between those of Durham and Asheville, it is likely that Greenville's emissions from municipal operations could also contribute just 1% of the emissions from the rest of the city. Alternatively, Greenville may fall slightly behind its peers in a community-wide analysis because Greenville Utility Commissions, the city's electricity provider, does not have quite as many renewables in its portfolio as Duke Energy, which is the major energy supplier for many other cities in NC.

VI. Discussion

The results of Greenville's baseline GHG emissions inventory indicate that the Vehicle Fleet sector has a considerable impact on the total emissions from their municipal operations. It is important to identify the largest contributing sector to narrow down and give direction to potential emissions reduction measures. For these reasons, we recommend that Greenville consider actions that will reduce emissions in future policy decisions, for example when vehicles are retired and replaced. Unfortunately, we were not able to make specific recommendations about sectors within the fleet that needed the most attention, as the data was not consistently broken down in ways that could provide further insight. We believe that there are more insights to be found within Greenville's fleet data, and that these will become apparent in the future as the city works to meaningfully disaggregate the data collected.

Regardless of the limited specificity within fleet data, our findings regarding fleet emissions are consistent with recent statewide findings that transportation now outweighs buildings in emissions intensity. The transportation sector is now the largest contributor to North Carolina's emission statewide (NC DEQ, 2022), and municipalities across the state will be reviewing their own fleets to reduce emissions and meet North Carolina emissions reduction goals. Greenville has the opportunity to partner with peers to encourage information sharing and implement policies to reduce emissions in the transportation sector that are consistent with municipalities across the state. This will become an increasing trend as local governments work to meet the transportation emissions goals set forth in NC Executive Order No. 246 (2022), which sets the expectation that zero-emission vehicles in the state number more than 1.25 million and make up at least 50% of in-state sales of new vehicles.

It is difficult to get a clear and accurate picture of where Greenville's GHG emissions stand in relation to other North Carolina municipalities. Many activities that municipal governments are typically responsible for, and which are included in their peer's local government inventories, are outsourced to other providers. Because the city is not operationally or financially responsible for these activities, they are not represented in Greenville's municipal emissions, and the city does not have operational control to implement emissions reductions measures within these sectors. These outlying operations not only limited our analysis and ability to meaningfully compare Greenville's emissions to its peers, but they limit the power of Greenville to enact meaningful change to certain operations. The sector that was of most concern in this regard was wastewater treatment, as it can represent a large portion of a city's reported emissions if included in an inventory. In 2007, wastewater treatment accounted for 22% of Asheville's total municipal emissions, and today appears to account for an even larger percentage of the city's emissions when compared to the rest of the municipal footprint (Edwards & Miller, 2021). However, most of the available data for other municipalities does not provide such a clear categorization of emissions, limiting the comparability of Greenville's per capita municipal emissions to those of its peers.

The primary limitations we faced in the project came from tradeoffs between accuracy and completeness. Improving the accuracy of emissions data can be a challenge due to unavailable data or expensive and time-consuming measurement processes. In order to improve completeness of our inventory, we made educated assumptions based on the raw data we received from the City of Greenville so we could convert it into the appropriate records or units required by ClearPath. Each assumption was well documented so that future inventories can be created following the same methodology if more precise or disaggregated data is not available. Another limitation was in the assumption that, for the business-as-usual scenario, emissions from municipal operations would grow proportionally to population growth and that population growth could be proportional to the national average. This assumption can be adjusted on an annual basis as better growth trajectories become available.

Overall, better tracking of data is crucial to be able to determine which actions are effective at reducing the city's emissions. Greenville should make it a priority to track emissions data with improved detail and accuracy by disaggregating measurements. This will allow the city to manage the emissions of each record as well as future reductions effectively. As Greenville creates emissions inventories for future years, and particularly if they create a community-wide emissions inventory, the city should also calculate their emissions per capita to benchmark their reduction efforts overtime as well as with other NC municipalities. Our project will be helpful to other mid-sized cities hoping to create a baseline GHG emissions inventory to analyze and reduce their emissions.

It is certainly important for Greenville to manage and reduce the emissions from their municipal operations before extending their attentions to the community at large. By doing so, the city conveys a message that this is an important area to address and improve in, and the city government could be a sustainability influencer who promotes and encourages climate-smart action for the health, well-being, and longevity of the city and its inhabitants. Thinking long-term, the city could make an even larger impact by increasing sustainability initiatives beyond government operations, and Greenville can look to the Community Action Plans of their four North Carolina peers for policies and recommendations that support reducing GHG emissions across the local community.

VII. Appendix A

Appendix A. A comprehensive list of all the emissions categories within ClearPath, along with the calculators possible for each. For each calculator than was used in our analysis, the required inputs are also provided.

Buildings & Facilities

- Emissions from Grid Electricity
  - Electricity use (kWh)
- Emissions from Stationary Fuel Combustion
  - Fuel type
  - Fuel use (MMBtu, gallons, or therms)
- Steam and District Heating Purchases
- Emissions from Electric Power Transmission and Distribution Losses
  - Electricity use (kWh)
  - Grid loss factor (%)
- Emissions and Removals from Trees Outside of Forests on Local Government Land
  - Canopy area (hectares or acres)
  - Emissions from tree loss ($MTCO_2e$)
  - CO_2 removals from existing trees ($MTCO_2e$)
- Emissions from Stationary Fuel Combustion (User Supplied Emissions Factors)
- Purchased District Cooling
- Heat and Power Purchases from Combined Heat and Power (CHP)
- Consumption of District Energy

Streetlights & Traffic Signals

- Emissions from Grid Electricity
  - Electricity use (kWh)
- Emissions from Stationary Combustion of Natural Gas
- Emissions from Electric Power Transmission and Distribution Losses
  - Electricity use (kWh)
  - Grid loss factor (%)

Vehicle Fleet

- Fleet Vehicle Emissions
  - fuel type
  - annual fuel use (gallons)
  - percent biofuel in blend (%)
  - VMT (miles)
  - VMT broken down by % passenger vehicle, light truck, and heavy truck
- Emissions from Off Road Vehicles
  - Equipment type
  - Fuel type
  - Fuel used (gallons)

Transit Fleet

- Transit Fleet Emissions
    - fuel type
    - annual fuel use (gallons)
    - vehicle type
    - percent biofuel in blend (%)
    - VMT (miles)
    - Passenger boardings per year
    - Service population

Employee Commute

- Employee Commute
    - Fuel type
    - Employee annual VMT
    - % VMT in passenger cars, light trucks, and heavy trucks
    - Total employees
- Employee Transit Use
    - Transit type
    - Employee passenger miles per year
- Employee Air Travel
    - Total employee aviation passenger miles

Electric Power Production

- Emissions from Electric Power Production, Calculated Externally
- Emissions from Electric Power Transmission and Distribution Losses

Solid Waste Facilities[1]

- Government Owned/Operated Landfill
- Waste Generation
    - Total waste generated (tons)
    - Landfill methane collection scenario
    - Landfill moisture content
    - Waste type
    - Data quality (low/medium/high confidence) of activity data and emissions factors
- Waste Generation (Alternative)
    - Total waste generated (tons)
    - Does landfill collect methane?
    - Note: this scenario is far less detailed, so the first is preferred if the data is available
- Emissions from Electric Power Transmission and Distribution Losses
- Emissions from Grid Electricity
- Emissions from the Combustion of Landfill Gas

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[1] For the scope of this project, we will focus solely on waste generation, as municipal government waste accounts for only a miniscule fraction of the waste at this facility. However, incorporating more of these calculations in future assessments will help to give a more complete picture of the government's indirect emissions.

- Combustion of Solid Waste
- Emissions from Stationary Fuel Combustion
- Emissions from Combustion of Landfill Gas by Flaring
- Composting Facilities

Water & Wastewater Treatment Facilities[2]

- Process N2O Emissions from Wastewater Treatment
- Process N2O from Effluent Discharge to Rivers and Estuaries
- Emissions from Stationary Fuel Combustion
- Emissions from Grid Electricity
- Process Emissions from Wastewater Treatment Lagoons
- Emissions from Electric Power Transmission and Distribution Losses
- Fugitive Emissions from Septic Systems
- Emissions from the Combustion of Digester Gas
- Emissions from Flaring of Digester Gas
- Emissions from the Incomplete Combustion of Digester Gas
- CO_2 Emissions from the Use of Fossil Fuel Derived Methanol
- Emissions from Combustion of Biosolids and Sludges

Process & Fugitive Emissions[3]

- Services Consumption
  - Service type
  - Cost per government employee
  - Number of employees
  - Life cycle emissions of service type[4] (g CO_2e/$)
- Construction Materials Consumption
  - Material type
  - Amount consumed (metric tons)
  - Life cycle emissions of goods type (mt CO_2e)
- Food Consumption
- Goods Consumption
- Hydrofluorocarbon & Refrigerant Emissions
- Upstream Impacts of Fuels Used in Stationary Combustion
- Other Process and Fugitive
- Fugitive Emissions from Natural Gas Distribution

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[2] Given the nature of the calculations within ClearPath, this category of emissions cannot be calculated with standard utility data and would require close collaboration with Greenville Utility Company. Since Greenville is only considering the treatment of wastewater from its own facilities, this will be included in Process & Fugitive Emissions.

[3] Data is not available for all relevant categories but should be recorded in the future for completeness.

[4] Values suggested by ClearPath tool based on service type, but manipulable

VIII. Appendix B

Appendix B. Images illustrating the uses of ICLEI membership and the ClearPath tool.

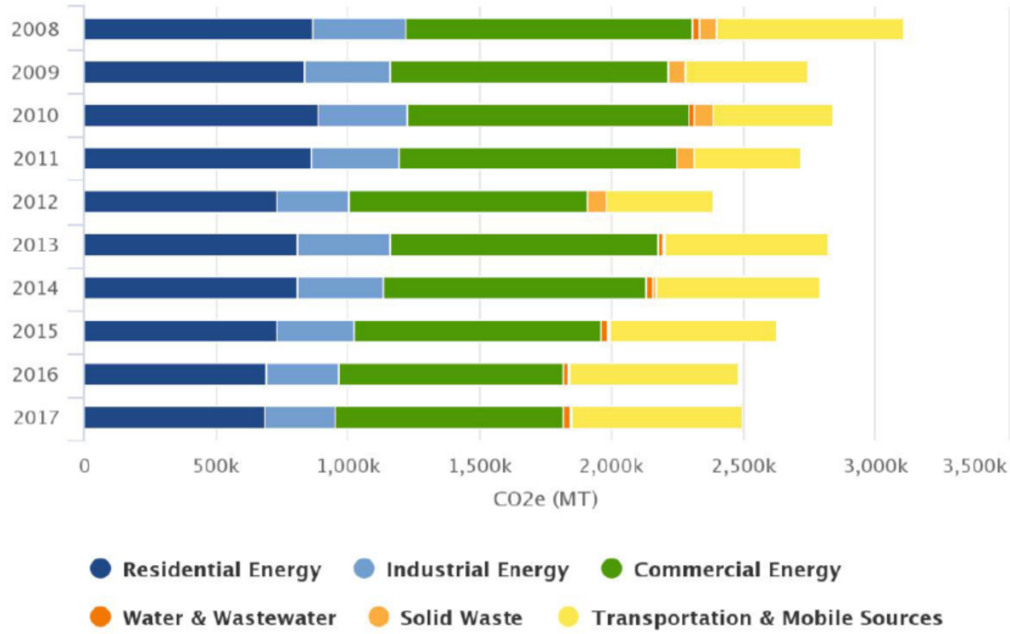

Figure B.1: Example comparison graph of year-to-year emissions by sector in ClearPath

Figure B.2: ICLEI's 5 Milestones for Climate Mitigation as illustrated by Brendle Group (2018)

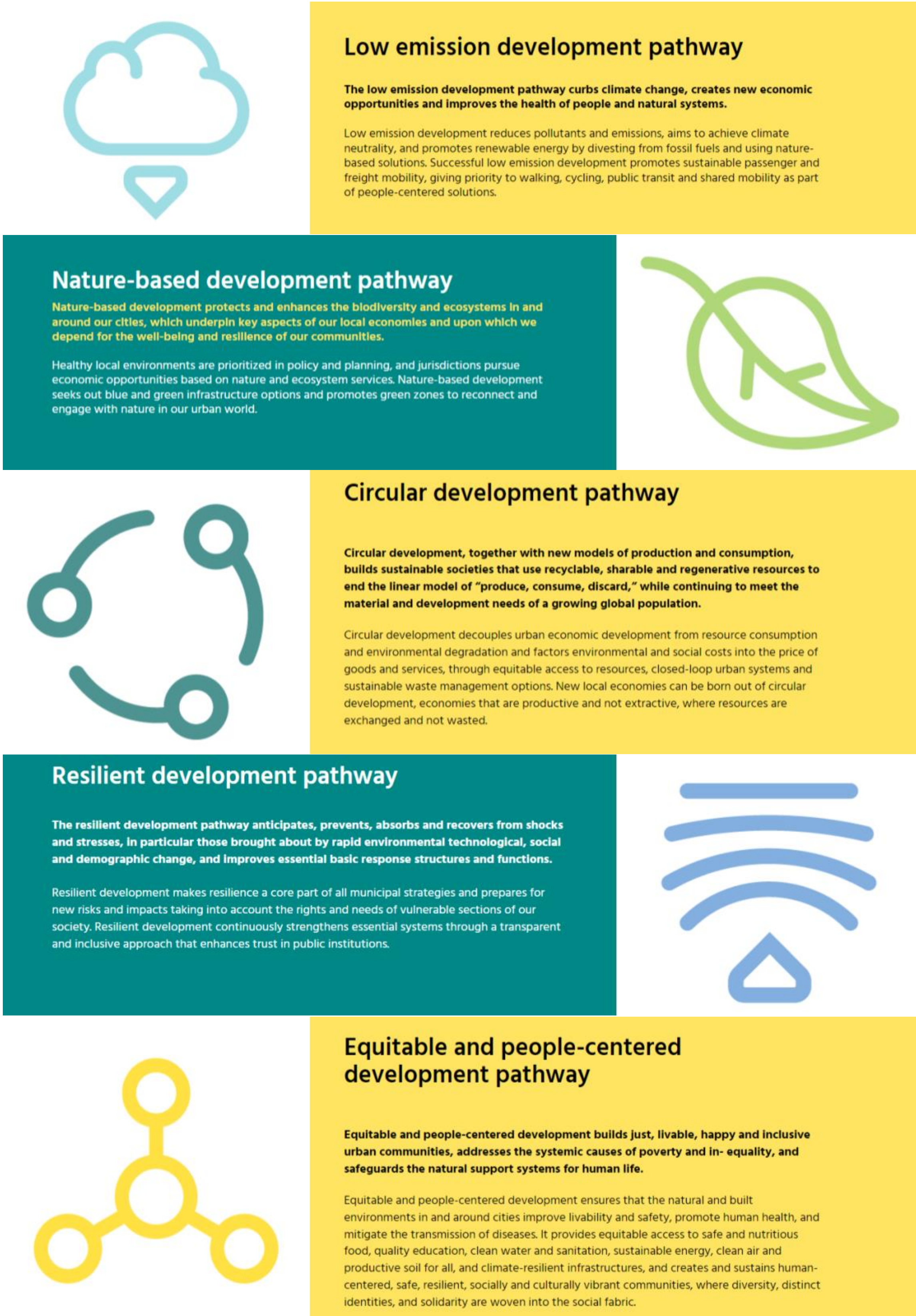

Figure B.3: ICLEI's 5 Pathways to a more sustainable world (ICLEI, n.d.)

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