

Carlisle Community Greenhouse Gas Inventory, 2022

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Table of Contents

Introduction.....	2
Residential	2
Electricity	
Natural Gas	
Non-Utility Stationary Fuels	
Commercial	3
Electricity	
Natural Gas	
Non Utility Stationary Fuels	
Industrial	5
Electricity	
Natural Gas	
Non Utility Stationary Fuels	
Waste	7
Process and Fugitive Emissions	7
Upstream Impacts of Activities	8
Transportation	8
On-road	
Off-road	
Rail	
Water and Wastewater	10
Energy	
Treatment	
Agriculture, Forestry and Other Land Use (AFOLU)	11
References	12
Appendix A	13
Appendix B	14
Appendix C	15

Introduction

Carlisle's 2022 greenhouse gas inventory was completed using ClearPath, an emissions management software from ICLEI-USA and is U.S. Community Protocol compliant. The inventory includes nine sectors which are addressed in detail below. Within each sector many calculators were used to determine emissions from specific activities. National factor sets were applied to data provided by utilities, Carlisle staff or found publicly, to calculate the emissions from each activity.

Residential

Electricity

Residential electricity usage was reported to the inventory team from the PPL electricity for the entire 17013 zip code. Because the community-wide inventory for Carlisle is only intended to represent the electricity usage within the borders of Carlisle, a population adjustment was performed on the zip code-level data to estimate the amount of electricity consumed by the borough of Carlisle. According to census data from censusreporter.org, the population of Carlisle is approximately 55.7% of the population within the 17013 zip code. Therefore, the PPL residential electricity usage multiplied by 0.557 represents the estimation for Carlisle's residential electricity. In 2022, the estimation resulted in a residential electricity usage for Carlisle at 9.2×10^7 kWh, which converts to approximately **28,227 metric tons of carbon dioxide equivalent (CO₂e) emissions²**. This value was less than the 2017 inventory reported value by less than one percent, which is likely within the margin of uncertainty for the population adjustment and can be considered a relatively unchanged value.

Natural Gas

Data regarding the usage of natural gas within the zip code of 17013 was provided directly from UGI Utilities. Again, a population adjustment was required to estimate the proportion of natural gas used by residents within the borders of Carlisle borough. Using the same 55.7% conversion as above, the greenhouse gas emissions due to natural gas were approximately **11,310 metric tons CO₂e**. This was a 4% increase over 2017 levels, which may partly fall within the margin of uncertainty from the population adjustment but likely reflects a small increase in residential natural gas usage nonetheless.

² Greenhouse gas emissions associated with electricity usage are calculated by converting total annual electricity usage in kilowatt-hours (kWh) to greenhouse gas emissions according to the Emissions and Generation Resource Integrated Database (eGRID) managed by the Environmental Protection Agency (EPA). The database compiles monitored and estimated data pertaining to the electric grid in different regions of the country and characterizes the greenhouse gas emissions that each region can expect to produce, on average, for each kWh of electricity consumed. Carlisle falls within the eGRID region "RFC East," which covers most of western Pennsylvania. In this inventory, we utilized the CO₂, CH₄, and N₂O emission factors.

Non-Utility Stationary Fuels

Residential non-utility fuel sources include kerosene, fuel oils, liquid petroleum and bottled tank gas used primarily for home heating purposes. Data identifying the number of households using each fuel type is taken from the US Census Bureau data and manipulated to allow for input into ICLEI's ClearPath. Calculating average usage of alternative fuels is based upon average usage of residential natural gas customers for home heating purposes. Upon determining average natural gas usage per customer, this usage data is applied to each fuel type using the household data obtained from the US Census Bureau. Carlisle Borough data indicates no Coal or Coke home heating usage and ICLEI's ClearPath methodology excludes 'Other fuels'. Considerable margins of error exist for non-utility stationary fuel sources and should be noted when considering the accuracy of the resulting data. Of note, the 2017 inventory uses interpretation of state-level data provided by the Energy Information Administration (EIA), a different source than ICLEI's ClearPath Inventory for 2022 Residential Non-Utility Stationary Fuels, but the same source as Commercial and Industrial Non-Utility Stationary Fuels in 2022. As a result, the resulting emissions are not directly comparable, but trends show between approximately 40-60% reduction in usage of both Kerosene/Fuel Oil and Bottled, Tank, or LP Gas (See Appendix C for data comparison).

Commercial

Electricity

In addition to the residential data, PPL Utilities provided electricity usage data for commercial, industrial, and municipal buildings. Again, the data was provided for the zip code 17013. For the municipal category, it was assumed that all government operators for Carlisle occurred within the boundary of the borough and thus no population adjustment was performed. Municipal electricity accounted for **6,464 MT CO₂e** and was included under the Commercial sector umbrella as ICLEI does not have the capability to add an electricity entry without specifying one of Residential, Commercial, or Industrial sectors.

For the Commercial entry, a population adjustment was required as commercial activity within the zip code of 17013 is not commensurate with commercial activity within Carlisle. Rather than simply using population though, the proportion of commercial activity in Carlisle was calculated by estimating the amount of commercial jobs within Carlisle compared to the amount of commercial jobs within the 17013 zip code. OnTheMap job reports generated using census data report the amount of jobs for both Carlisle and 17013, but do not designate whether those jobs are commercial or industrial.

Absent a specific breakdown of categorization by PPL, the inventory team decided to categorize the listed jobs as either commercial or industrial using Google searches and general

impressions to try to replicate the designation process performed by PPL. Ultimately, all job categories except mining and manufacturing were selected as commercial. This estimation introduces a potential source of error as a misplaced category may over and underestimate the commercial and industrial electricity entries, or vice versa.³

Using the commercial jobs adjustment, electricity in the commercial sector generated **58,226 metric tons CO₂e** in 2022. This emissions estimate also includes a subtraction of electricity used for water and wastewater, which is accounted for in the appropriate section, but was initially included among the PPL utility data.

Natural Gas

The natural gas consumption data for the commercial sector was provided directly from UGI utilities alongside residential and industrial entries. The job-based adjustment was performed identically to the adjustment performed in the electricity section above, using 76.2% as the percentage for commercial jobs in Carlisle relative to the zip code 17013. The emissions for community natural gas in 2022 totaled approximately **20,741 metric tons CO₂e**. It should be noted that the same potential introduction of error using the job-based adjustment applies to this section as well. Also, this emissions estimate further includes a subtraction of natural gas used for water and wastewater, which is accounted for in the appropriate section, but was initially included among the UGI utility data.

Non-Utility Stationary Fuels

Commercial Non-Utility Stationary Fuel entries included Coal, Kerosene, Distillate Fuel Oil, HGL (Assumed Propane Only), Motor Gasoline, and Wood. These fuel sources were used mainly for heating purposes in commercial applications and properties. Data was obtained through EIA State Energy Data System (SEDS) at the state level. Adjustments were applied to the state level data using Carlisle Borough commercial jobs (as categorized above) as a ratio of Pennsylvania Jobs. The 2017 inventory provided entries for ‘Non-residential’ Propane and ‘Non-residential’ Fuel Oil. In total, commercial non-utility stationary fuels resulted in **7591 MT CO₂e** in the 2022 inventory and **9121 MT CO₂e** in the 2017 inventory. As noted above, the 2017 inventory did not separate out Commercial and Industrial data from one another and were instead aggregated into ‘non-residential’ under the commercial section, thus the 2017 total non-utility stationary fuel emissions include both industrial and commercial data.

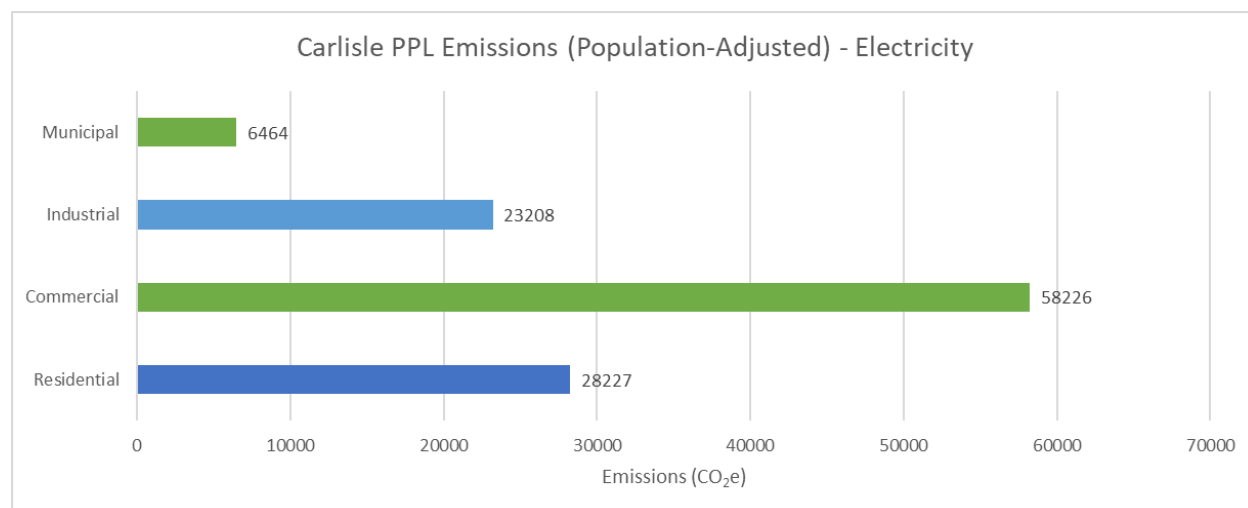
³ The resulting ratios for commercial and industrial jobs within Carlisle Borough relative to the zip code were 76.2% and 85%, respectively. The overall ratio of jobs before category allocation was 77.3%. Therefore, even with the error potentially introduced, the team is confident that the ratio of jobs is accurate within approximately ten percent as it is likely not substantially different from the overall ratio of jobs.

Industrial

Electricity

Emissions from industrial electricity usage were calculated side-by-side with the commercial calculation due to the relationship between job categories described above. Accordingly, the industrial job-based adjustment amounted to 85% of 17013 industrial jobs within Carlisle. Further, the use of electricity by the industrial sector generated **23,208 metric tons CO₂e** in 2022. Although some of the increase may be attributable to error introduced by the assumptions made during job-based calculations, the significance of the increase suggests that the increase is likely due to consumption increases of electricity in non-residential buildings.

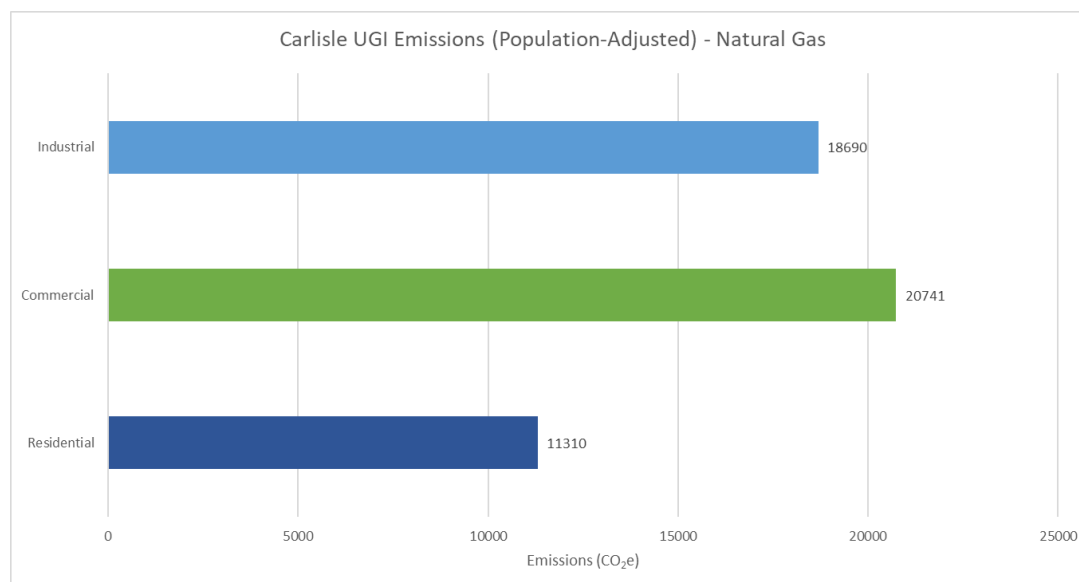
The 2017 inventory aggregated non-residential categories instead of having separate commercial and industrial categories. The data for commercial and industrial categories are summarized in Appendix A as non-residential to allow for a direct comparison with 2017 values. Comparing the total of commercial, industrial, and municipal electricity consumption in 2022 to the non-residential entry in 2017 results in a **6%** increase. This small of an increase may be countered entirely by the range of uncertainty introduced by the job categorization assumption. However, it is more likely than not that there was a small increase in non-residential electricity emissions. The different sectors' electricity emissions for 2022 are compared below.



Natural Gas

Industrial natural gas usage, provided directly by UGI utilities, used the same job-based adjustment as was used in the Industrial Electricity section above for 85% of industrial jobs within the zip code of 17013. Natural gas from industrial uses generated **18,690 metric tons CO₂e** in 2022. Comparing the total of commercial and industrial natural gas entries in 2022 to the non-residential entry in 2017, there has been a **36%** increase in the carbon dioxide-equivalent emissions. Although some of the increase may be attributable to error introduced by the

assumptions made during job-based calculations, the significance of the increase suggests that the increase is likely due to consumption increases of natural gas in non-residential buildings. The different sectors' natural gas emissions for 2022 are compared below.



Non-Utility Stationary Fuels

Industrial Non-Utility Stationary Fuel entries included the same categories as Commercial Non-Utility Stationary Fuel data obtained from the same EIA SEDS database. The 2017 inventory did not include an industrial section and as a result does not have data to compare against directly. In total, Industrial Non-Utility Stationary Fuels accounted for **70,537.13 MT CO₂e** in 2022. Of note, coal accounted for **52,680 MT CO₂e** of the total Non-Utility Stationary Fuels emissions. Without the inclusion of coal, industrial sector Non-Utility Stationary Fuels accounted for a total of **17,857.13 MT CO₂e**. To compare to the commercial/non-residential sources of the 2017 inventory, when combined with 2022 Commercial Non-Utility Stationary Fuels (excluding coal), the 2022 total was **25,448.13 CO₂e** as compared with **9,121 MT CO₂e** in 2017. Applying the same methodology used in the 2022 inventory (an admittedly flawed method) with the 2017 EIA SEDS data on coal usage and 2017 inventory emissions factors results in **53,480 MT CO₂e** total emissions attributed to industrial coal usage as a non-utility stationary fuel source, a similar number to 2022. The coal fuel type chosen for the inventory was Bituminous, owing to its prevalence in Pennsylvania-based extraction.

Waste

The data used to estimate emissions from the waste sector was provided by Jared Woolston, Director, Sustainable Community & Economic Planning Borough of Carlisle. The data included waste generation totals and per person for Cumberland County between 2019 and 2023. The per person totals were used to estimate the amount of municipal waste generated within the Carlisle Borough in 2022. The entry was then submitted in tonnage to ICLEI's Clearpath, which was equipped with a factor set characterizing the composition of the waste.⁴

Using this factor set, the tonnage of municipal waste was estimated to have generated **1,302 metric tons CO₂e** in 2022. Yard waste tonnage was also provided by Jared Woolston and was assumed to be entirely within the limits of Carlisle Borough as the volume breakout was not readily available nor the serviced area. Emissions from yard waste composting totaled **135 metric tons CO₂e**.

Additionally, data from Dusty Hilbert at Advanced Disposal was provided regarding the landfill at which Carlisle's municipal waste is hauled. The data included the cubic feet of landfill gas collected and combusted at the landfill as well as the methane content of the gas. It was assumed that the amount of gas at the landfill originating from Carlisle waste was proportional to the population of Carlisle relative to Cumberland County. The population adjustment for this section yielded 7.7% of the county population. Thus the amount of gas combusted and flared was multiplied by 7.7% to yield emissions of **11 and 189 metric tons CO₂e**, respectively.

Process & Fugitive Emissions

Inherent to the process of utility-scale distribution of natural gas, some natural gas leaks to the environment in the form of CH₄, a greenhouse gas. These emissions can be accounted for by assuming that a fixed percentage, 0.3% in this case, of all distributed natural gas is leaked to the environment. Therefore, each entry for utility-scale natural gas—in residential, commercial, industrial, and water/wastewater sectors—involve fugitive emissions. Water and wastewater were combined for clarity in emissions values and because each emissions entry would be insignificant to the inventory on its own. The resulting fugitive emissions were **369, 785, 611, and 11 metric tons of CO₂e, respectively**.

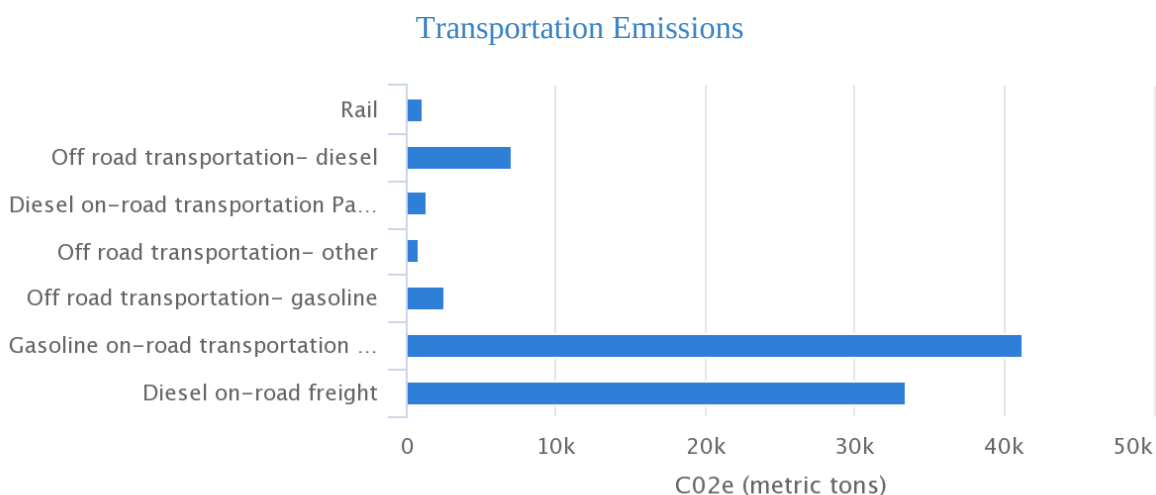
⁴ The factor set used values from the Pennsylvania Department of Environmental Protection's 2022 Statewide Waste Composition study.

Upstream Impacts of Activities

Analogous to the fugitive emissions for natural gas, there is a certain amount of electricity loss associated with transmission and distribution of electricity. This loss is accounted for by eGRID factors and, for RFC East, a 4.5% loss rate may be assumed. Therefore, for residential, commercial, industrial, municipal, and water/wastewater, emissions due to electricity loss were calculated as **1,270, 2,620, 1,044, 291, and 77 metric tons CO₂e**, respectively.

Transportation

The transportation sector accounts for **87,366 metric tons CO₂e**, making it Carlisle's third largest emitting sector. The three main emitting activities are on-road transportation, off-road transportation and rail. This inventory did not include aviation, which was in the 2017 inventory.



On-road transportation.

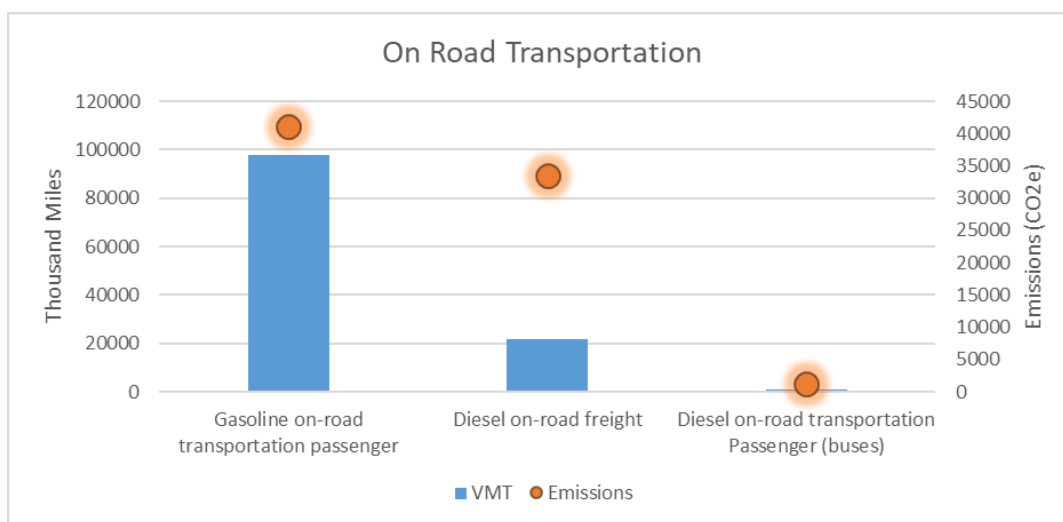
Three calculators were used to fully capture on-road activities; gasoline passenger travel, diesel passenger travel (buses) and diesel freight travel. Within the gasoline category, further distinctions were made between motorcycles, passenger cars, light trucks and heavy trucks to most accurately capture emissions per vehicle miles traveled (VMT)⁵. Gasoline powered passenger vehicles were responsible for the most VMT and emissions, 96.7 million miles and **41,189 metric tons CO₂e**⁶. Diesel powered freight vehicles accounted for the second largest

⁵ [2021 PA Highway Statistics](#) was used to determine the percentage of vehicle miles traveled by functional classification. This breakdown was used in Clear Path along with a Vehicle Miles of Travel Summary for Carlisle Borough to determine the exact number of miles traveled within Carlisle within each vehicle class.

⁶ Gasoline passenger vehicles include classes 1,2,3 and 5.

share with 21.5 million miles and **33,475 metric tons CO₂e**⁷. Diesel powered passenger vehicles (buses), accounted for only .83 million miles and **1,294 metric tons CO₂e**⁸.

The chart below shows the miles and emissions associated with each vehicle category. It is clear that the emissions per mile traveled for diesel freight vehicles is higher than for gasoline or diesel passenger vehicles.



Gasoline passenger emissions increased by 33% from 2017 while VMT only increased by 17%. This is likely due to an increase in the precise number of miles driven by each class of vehicles within the passenger classification. The 2017 inventory associated 95% of VMT to passenger vehicles and 5% to light trucks while the 2022 inventory includes more categories.

Off-road transportation

Transportation off-road emissions arise from agricultural, commercial, construction, industrial, lawn and garden, logging and recreational equipment powered by gasoline, diesel and other fuels. This data was only available from the EPA National Emissions Inventory for 2020 at the county level. The emissions for Cumberland County were scaled down by 7.7% to represent the emissions associated with Carlisle as Carlisle represents 7.7% of Cumberland County's population. There are limitations to the precision of this data as it is not possible to know if the emissions are spread evenly throughout Cumberland County. Off road transportation is responsible for **10,367 metric tons CO₂e**. Off-road transportation was not included in the 2017 inventory.

⁷ Diesel freight vehicles include vehicle classes 6 through 13.

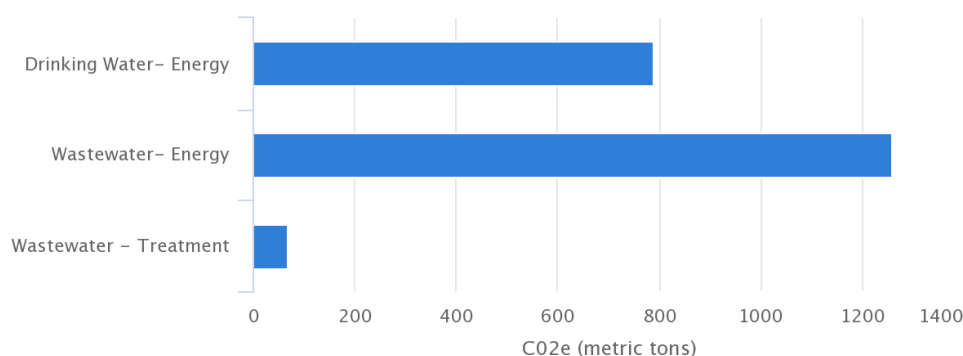
⁸ Diesel passenger vehicles include vehicle class 4.

Rail

Emissions associated with Norfolk Southern train operations were determined using an EPA provided calculation (Bergin et al., 2012). They were then scaled down according to the miles of train tracks within Carlisle's boundaries to determine **1,040.7 metric tons CO₂e are emitted by train traffic in Carlisle**. 2022 rail emissions were 35% that of 2017, this is likely due to a change in methodology.

Water and Wastewater

Water and Wastewater Emissions



Energy

The water and wastewater calculators measure the energy used to run the Carlisle's water systems. **1,260 metric tons CO₂e** are produced from powering the sewer plants operated by Carlisle and **790 metric tons CO₂e** are attributed to the water plant, pump stations, and water tanks operated by Carlisle departments. The energy used by the water and wastewater infrastructure was removed from the Commercial Natural Gas and Commercial Municipal and Other Electricity Use calculators.

Emissions associated with the energy used to run the wastewater treatment infrastructure increased 53% and energy emissions associated with drinking water increased 31% from the 2017 inventory. It is likely in 2017 the energy and emissions data was scaled down to remove emissions associated with those living outside of Carlisle. For the 2022 inventory we opted to include 100% of the emissions associated with drinking water and wastewater because they are operated by Carlisle Borough.

Treatment

The treatment of wastewater produces greenhouse gasses through enteric fermentation. Emissions were calculated in ClearPath and based on the population served by the wastewater facility, equaling **69 metric tons CO₂e**. Emissions from wastewater treatment increased 56% between the 2017 inventory and the 2022 inventory. Again some of this increase can be attributed to the updated method of including all emissions associated with the facility rather than a reduced attribution based on population.

Overall, the water and wastewater sector accounts for .61% of Carlisle's emissions. All water and wastewater data was provided by Jared Woolston, Director, Sustainable Community & Economic Planning, Borough of Carlisle.

Agriculture, Forestry and Other Land Use (AFOLU)

The Agriculture, Forestry, and Other Land Use section of greenhouse gas inventories is complex and often imprecise due to the difficulty of acquiring accurate data and the changing understanding of the sector's impacts on emissions.

This inventory includes seven calculations related to forestry and land use which are marked as "information only" and do not count towards Carlisle's emissions. The data was collected through the ICLEI Learn Tool and was only available on the county level. The entries are for all of Cumberland County because it is not feasible to scale the emissions from the county level accurately.

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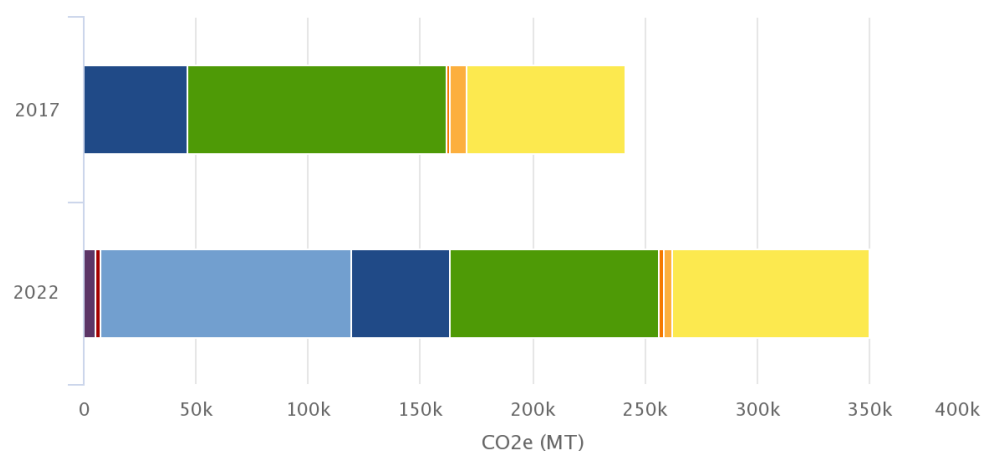
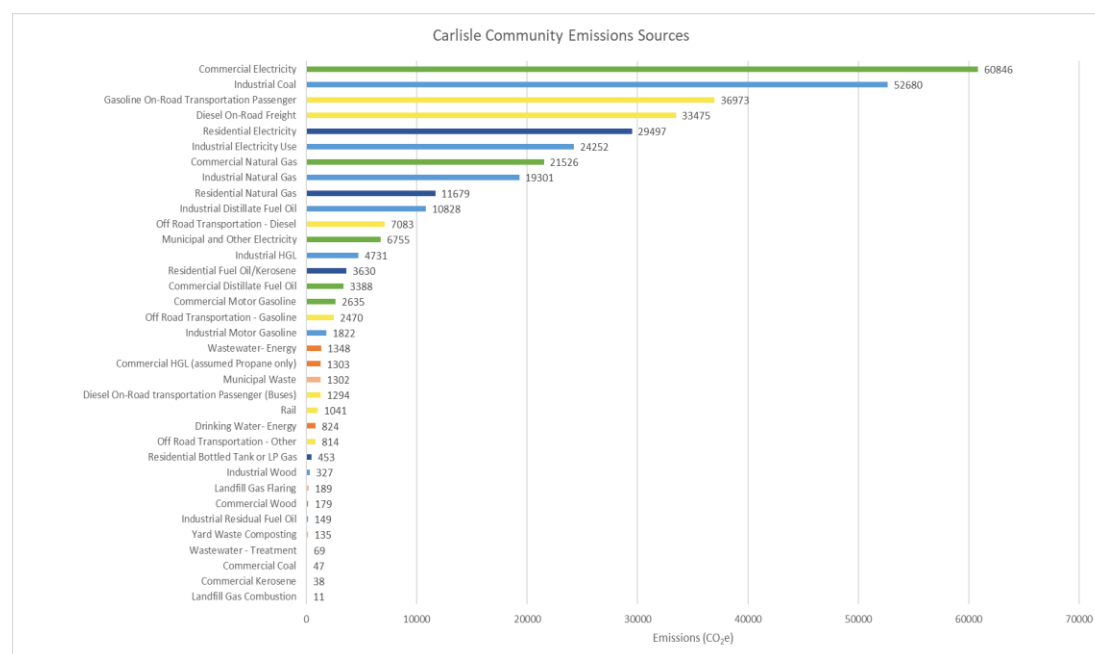
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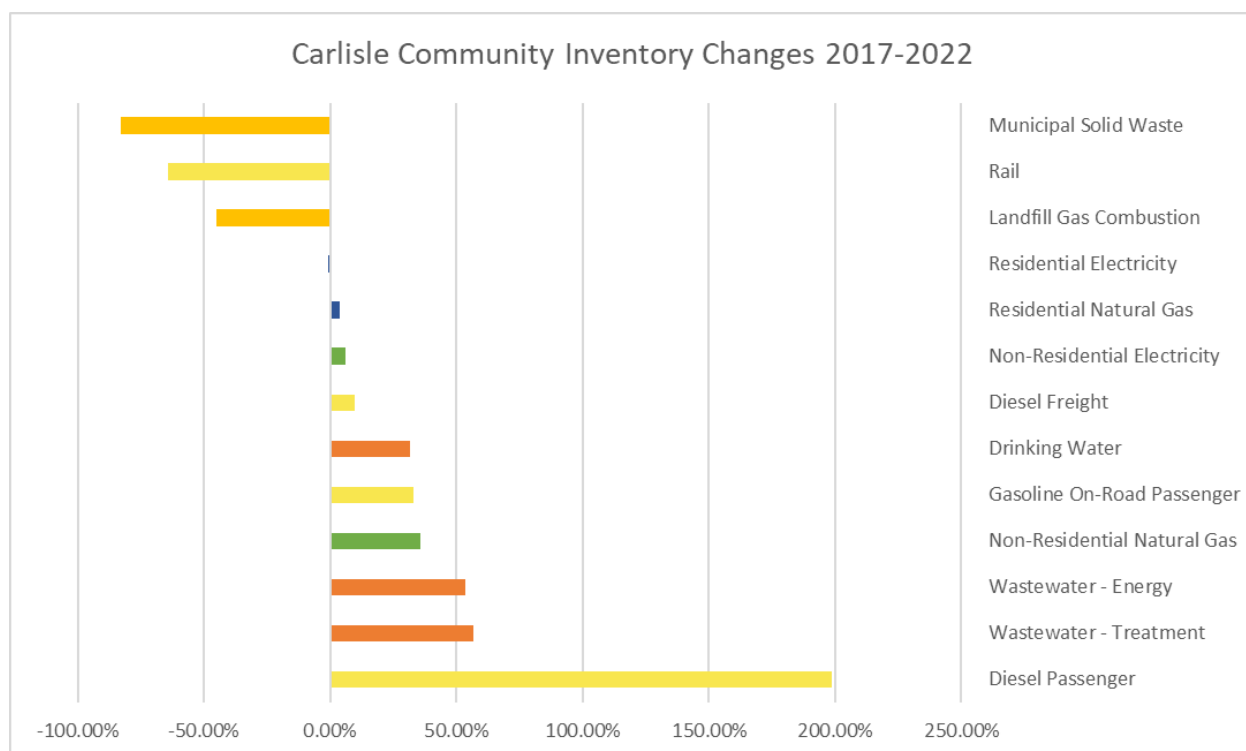
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Appendix A: 2022 Summary Figures

In both the fugitive emissions section and the upstream impacts section, the additional associated emissions outside of the original entry were included in the total accounted for in any particular source. For example, municipal electricity produced 6,464 metric tons CO₂e and electricity loss from this usage further resulted in 291 metric tons. The total reported value for the summary graph below is 6,755 metric tons CO₂e.



Appendix B: Comparison Figures for 2017 and 2022 Carlisle Community Inventories

Appendix C: Carlisle Borough Residential Non-Utility Stationary Fuels Data

	Occupied housing units			
Label	Estimate	Margin of Error	2017 Usage (CO ₂ e(MT))	2022 Usage (CO ₂ e(MT))
HOUSE HEATING FUEL				
Utility gas	4,080	±382	10877	11310
Bottled, tank, or LP gas	140	±72	1054.4	452.86
Electricity	2,732	±296	28391	28227
Fuel oil, kerosene, etc.	920	±210	5845.5	3630.4
Coal or coke	0	±18		
All other fuels	104	±103		
No fuel used	123	±81		