Martinsville, Virginia
Community Greenhouse Gas Inventory

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Introduction

The City of Martinsville is located in the center of Henry County, Virginia. With a population of 13,485, local government officials have requested that an inventory be taken of greenhouse gas emissions from the year 2022. Partnering with ICLEI Local Governments for Sustainability, students at George Mason University have undertaken the process of collaborating with local government officials to compile greenhouse gas emissions data, and present it for the benefit of the City of Martinsville. The following Community greenhouse gas inventory includes detailed reports of each sector and its emissions.

What is a Community Greenhouse Gas (GHG) Inventory?

A Community greenhouse gas (GHG) inventory is a systematic and comprehensive assessment of all GHG emissions produced within a specific community or geographic area. This inventory provides a detailed account of the sources and amounts of greenhouse gasses released into the atmosphere as a result of human activities within the community of Martinsville.

Key elements of a Community GHG inventory include:

1. **Emission Sources** - Electricity, Transportation, Solid Waste, Water and Wastewater, AFOLU (Agriculture, Forestry, and Other Land Use), Fugitive Emissions, and Grid Loss.
2. **Greenhouse Gasses** - Measurement of different types of greenhouse gasses such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and refrigerants. Each gas contributes to climate change with varying potential.
3. **Data Collection** - Where the data comes from such as vehicle miles traveled, reports from utility companies, and other relevant factors.
4. **Inventory Period** - The time frame in which the inventory is taking place.

Greenhouse Gas Inventory 2022

Total Emissions

Martinsville's total greenhouse gas emissions in 2022 are estimated to be 169,091 metric tons of carbon dioxide equivalent (CO2e). CO2e is a conversion of other greenhouse gasses, such as methane, to an amount of carbon dioxide with an equivalent amount of warming potential. Emission estimates were taken from internal sources, such as the Water Resources Department, and external sources, such as Southwestern Virginia Gas. In general, estimates from municipal and utility sources are higher quality that external sources such as EIA estimates. To convert the provided data into CO2e, ICLEI's ClearPath tool used various emissions factors depending on the data source based on Science-Based Target (SBT) guidance. Emissions data was categorized into the following: Residential Energy, Commercial Energy, Industrial Energy, Transportation, Solid Waste, Water and Wastewater, AFOLU (Agriculture, Forest, and Land Use), Fugitive Emissions, and Grid Loss.

Per capita emissions for Martinsville are about 12.6 metric tons of CO2e. While this is lower than the US average of 16, it is important to keep in mind that this only includes emissions for Martinsville and doesn't include other factors like air travel (The Nature Conservancy, 2023). It's also important to note that per capita emissions tend to be lower for urban areas and higher for rural ones. Municipal emissions are also

comprised of out of boundary services. For a comparison, Danville has emissions of roughly 650,000 CO2e, which is per capita about 15.4 metric tons of CO2e.

Emissions by Sector

Figures 1 and 2 illustrate how total emissions of 169,091 are divided into sectors. From highest to lowest amounts of CO2e emissions, the sectors are:

- Residential Energy - 48,857 CO2e
- Commercial Energy - 44,145 CO2e
- Transportation - 43,883 CO2e
- Industrial Energy - 17,226 CO2e
- Solid Waste – 7,257 CO2e
- Water and Wastewater - 3,869 CO2e
- Grid Loss - 3,244 CO2e
- Fugitive Emissions – 610 CO2e

The majority of emissions fall under the energy and transportation sectors, which is typical for the US.

Figure 1, Emissions by Sector

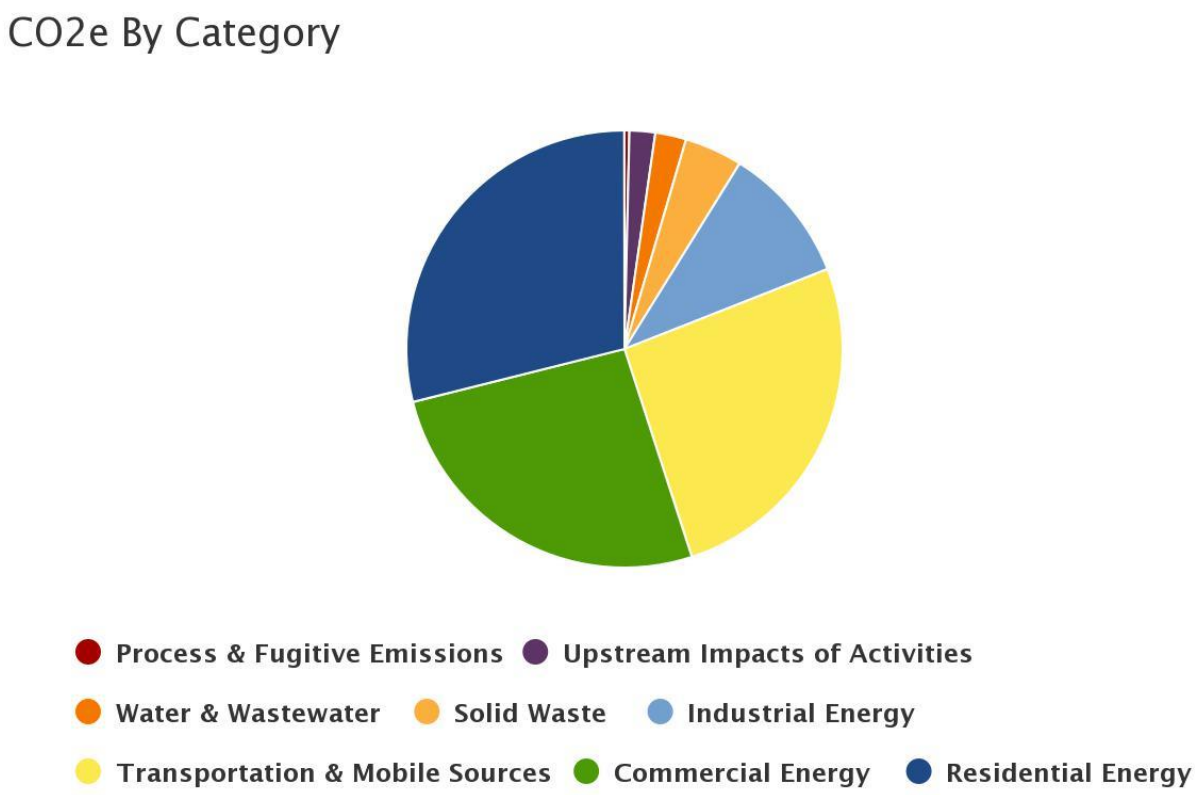
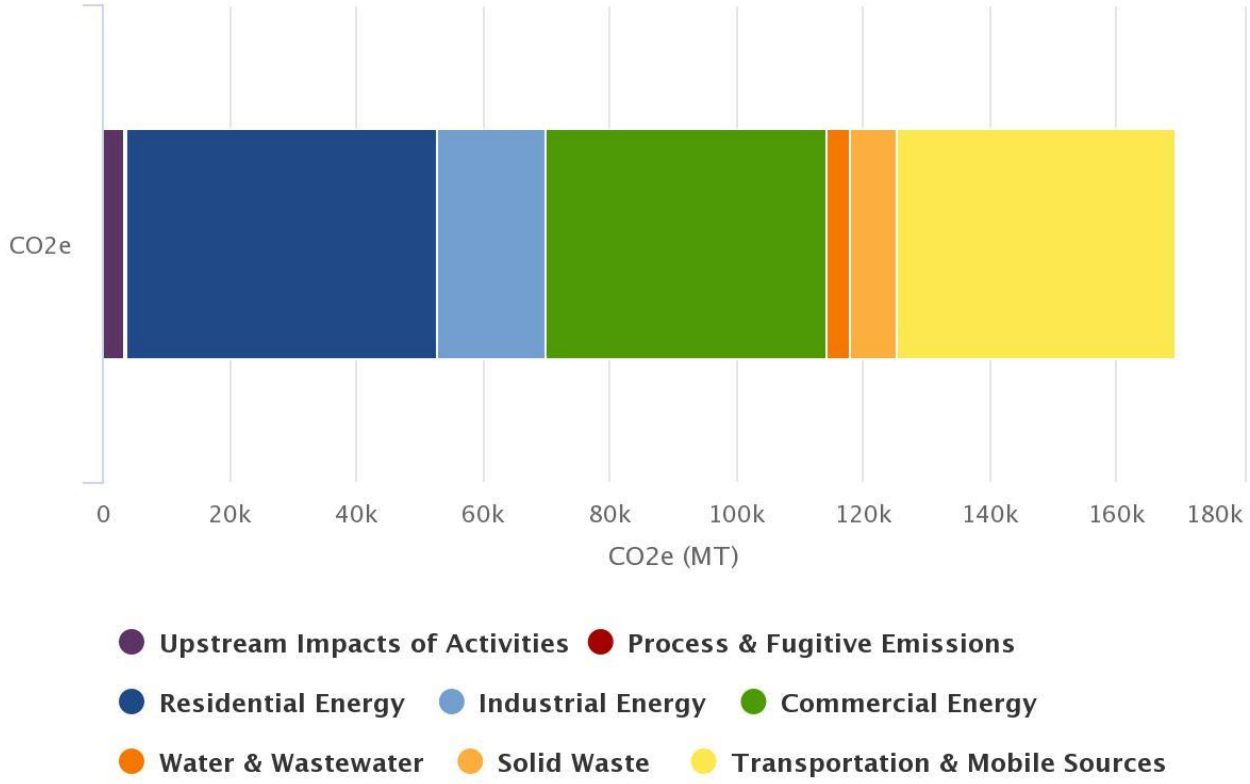


Figure 2, Emissions by Sector

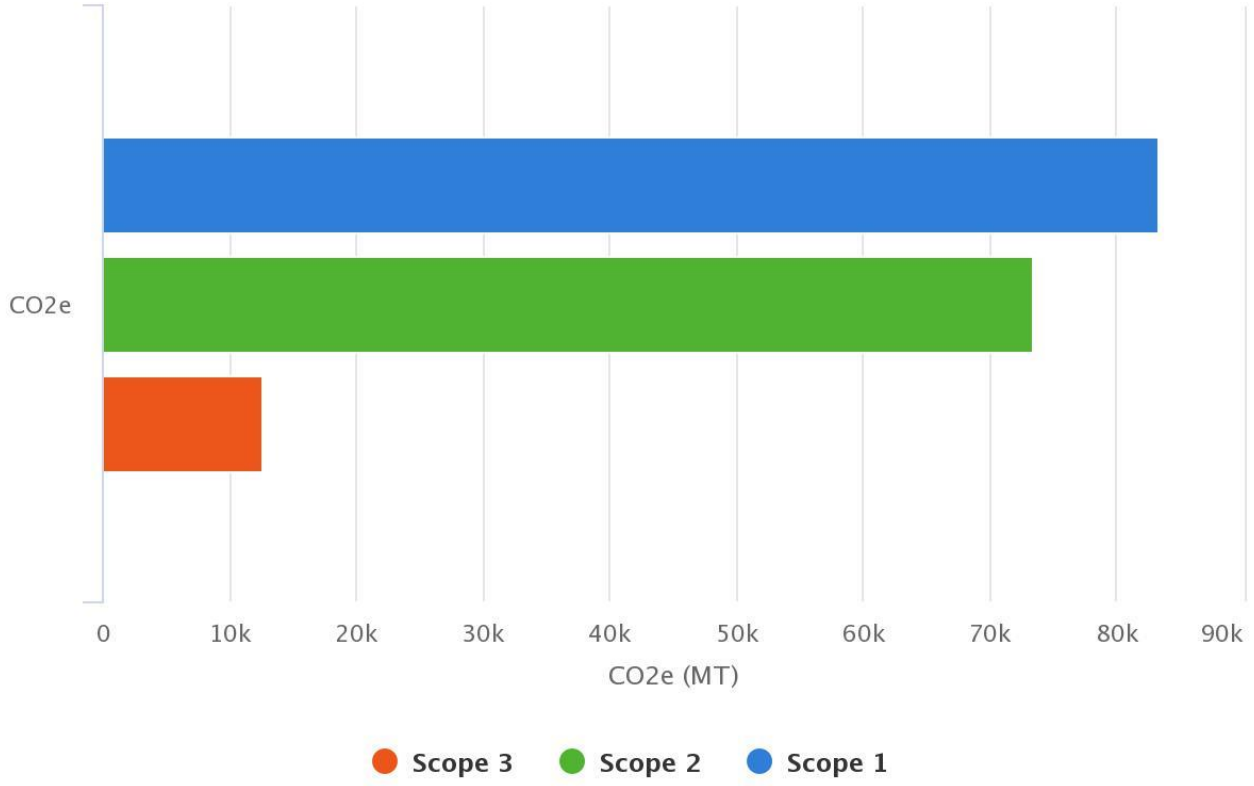


Inventory by Scope

Greenhouse gas emissions can also be divided up into scope 1, 2, or 3. Figure 3 represents Martinsville's emissions divided by scope.

- Scope 1 emissions are directly made by an entity.
    - Ex: Transportation, since it takes place within Martinsville's borders
    - Scope 1 emissions – 83,207 CO2e
- Scope 2 are emissions that an entity indirectly makes and are primarily from purchasing energy.
    - Ex: Energy purchased for heating and cooling homes.
    - Scope 2 emissions - 73,296 CO2e
- Scope 3 are emissions an entity is indirectly responsible for, but result from its activities
    - Ex: Solid waste produced by residents and sent to a landfill outside of Martinsville's boundaries
    - Scope 3 emissions – 12,589 CO2e

Figure 3, Emissions by Scope



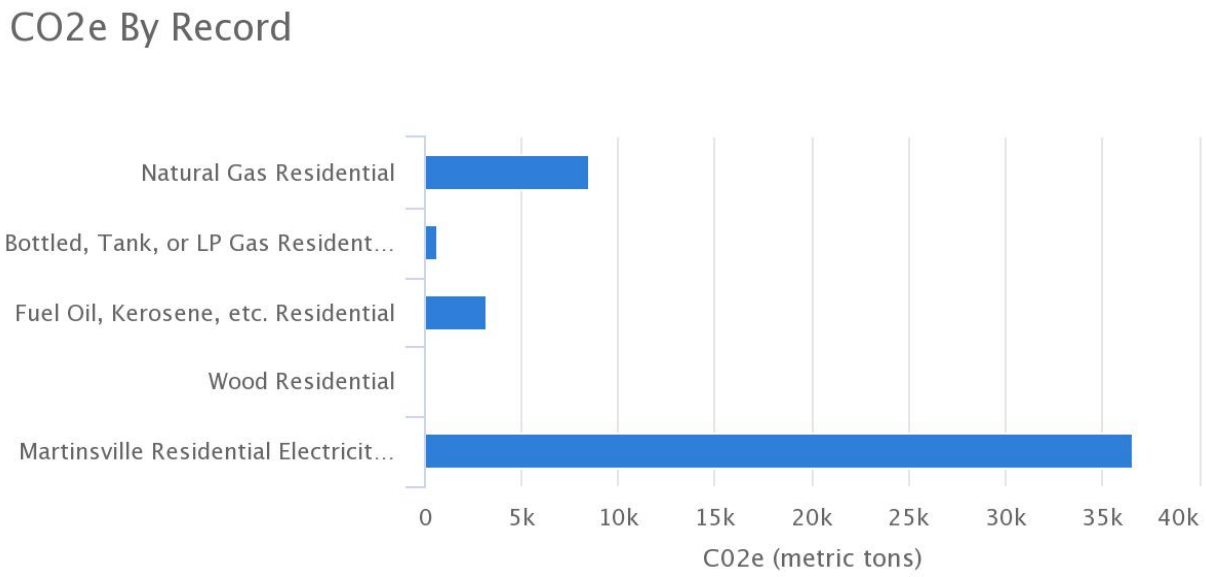
Residential Energy

Emissions from residential energy were calculated from the 2021 US Census Bureau's House Heating Fuel (B25040) Index and internal data obtained from Martinsville officials. These reports allowed us to estimate the 2022 emissions for the residential energy sector for Martinsville. Residential emissions are also divided up by type allowing for a more accurate emissions estimate. The categories are:

1. Residential Electricity - The electricity used totaled 36,618 metric tons of CO2e emitted. This number was calculated from data obtained from Martinsville.
2. Natural Gas Residential - Total Natural Gas use is 8,449 metric tons of CO2e. The data was obtained from Southwestern VA Gas.
3. Other Stationary Fuels - Measured by using EIA's Virginia Non-liquid fuels consumption 2021 data and the US Census Bureau's House Heating Fuel (B25040) Index for Martinsville, VA.
    a. Bottled, Tank, or LP Gas – 602 metric tons CO2e
    b. Fuel Oil and Kerosene – 3,170 metric tons CO2e
    c. Wood – 19 metric tons CO2e

Total emissions for the entire residential energy sector are 48,885 metric tons of CO2e.

Figure 4, Emissions from Residential Energy



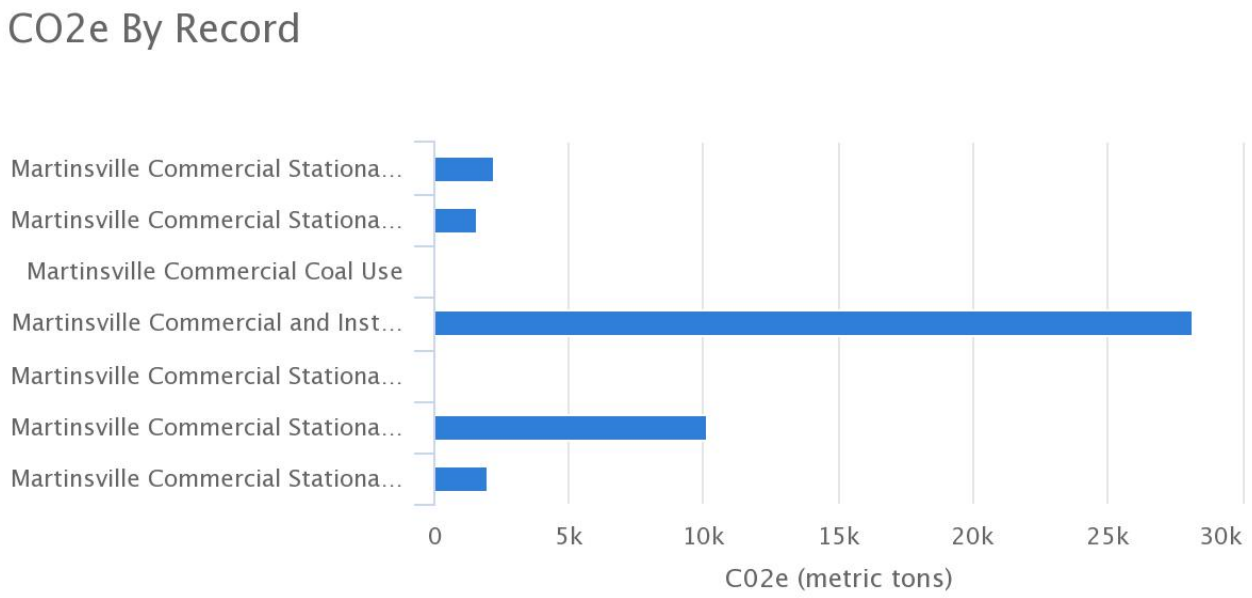
Commercial Energy

Emissions from commercial energy were calculated from the 2021 US Census Bureau's House Heating Fuel (B25040) Index and internal data obtained from Martinsville officials. These reports allowed us to estimate the emissions for the commercial energy sector for the year 2022 for each municipality in Virginia. Commercial emissions are also divided up by type, allowing for a more accurate emissions estimate. The categories are:

1. Commercial and Institutional Electricity Use - Electricity use is estimated to be 28,145 metric tons of CO2e. Data for this was provided by Martinsville.
2. Commercial Stationary Natural Gas - Total natural gas usage is 10,166 metric tons of CO2e. Data was provided by Southwestern VA Gas.
3. Other Stationary Fuels - The US Census Bureau's "OnTheMap" and EIA's "Commercial Sector Energy Consumption Estimates 2021" tools were used to estimate fuel usage by number of jobs in the Commercial Sector in Martinsville.
    a. Motor Gasoline – 2,205 metric tons CO2e
    b. Distillate Fuel Oil – 1,620 metric tons CO2e
    c. HGL – 1,994 metric tons CO2e
    d. Kerosene – 15.17 metric tons CO2e
4. Commercial Coal Use - Since anthracite and bituminous coal are the types of coal used the most in the region, we averaged their emission factors. Otherwise, the same method was used for a total of 0.5 metric tons of CO2e.

In total, the emissions resulting from commercial electric consumption are 44,145 Metric Tons of CO2e.

Figure 5, Emissions from Commercial Energy



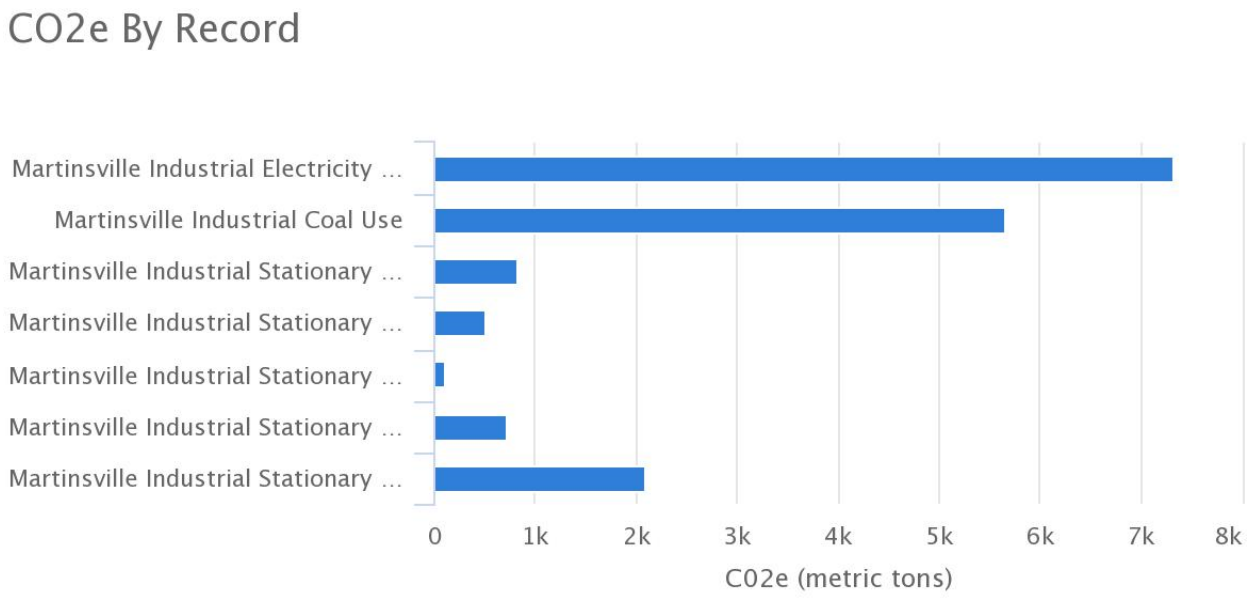
Industrial Energy

Emissions from industrial energy were calculated from the 2021 US Census Bureau's House Heating Fuel (B25040) Index and internal data obtained from Martinsville officials. These reports allowed us to estimate the emissions for the industrial energy sector for the year 2022 for each municipality in Virginia. Industrial emissions are also divided up by type, allowing for a more accurate emissions estimate. The categories are:

1. Industrial Electricity Use - Electricity use is estimated to be 7,332 metric tons of CO2e. Data for this was provided by Martinsville.
2. Industrial Natural Gas - Total natural gas usage is 823 metric tons of CO2e. Data was provided by Southwestern VA Gas.
3. Other Stationary Fuels - The US Census Bureau's "OnTheMap" and EIA's "Industrial Sector Energy Consumption Estimates 2021" tools were used to estimate fuel usage by number of jobs in the Industrial Sector in Martinsville.
    a. Motor Gasoline – 514 metric tons CO2e
    b. Distillate Fuel Oil – 2,080 metric tons CO2e
    c. HGL – 722 metric tons CO2e
    d. Kerosene – 106 metric tons CO2e
4. Industrial Coal Use - Since anthracite and bituminous coal are the types of coal used the most in the region, we averaged their emission factors. Otherwise, the same method was used for a total of 5,650 metric tons of CO2e.

As a result of all these calculations, we found that in total, the emissions resulting from the industrial electric consumption represented 17,227 Metric Tons of CO2e

Figure 6, Emissions from Industrial Energy



Transportation

Emissions from transportation were calculated from the Department of Transportation's "Vehicle Miles Traveled" report. This report estimates the miles traveled for the year 2021 for each municipality in Virginia, which is the most recent year available when the inventory was conducted. Vehicles miles traveled are also divided up by vehicle type allowing for a more accurate emissions estimate since vehicles can be divided up into categories which use different emissions factors and fuel sets. The factor set used for this inventory is the "2021 US National Defaults" provided by ICLEI. The categories are:

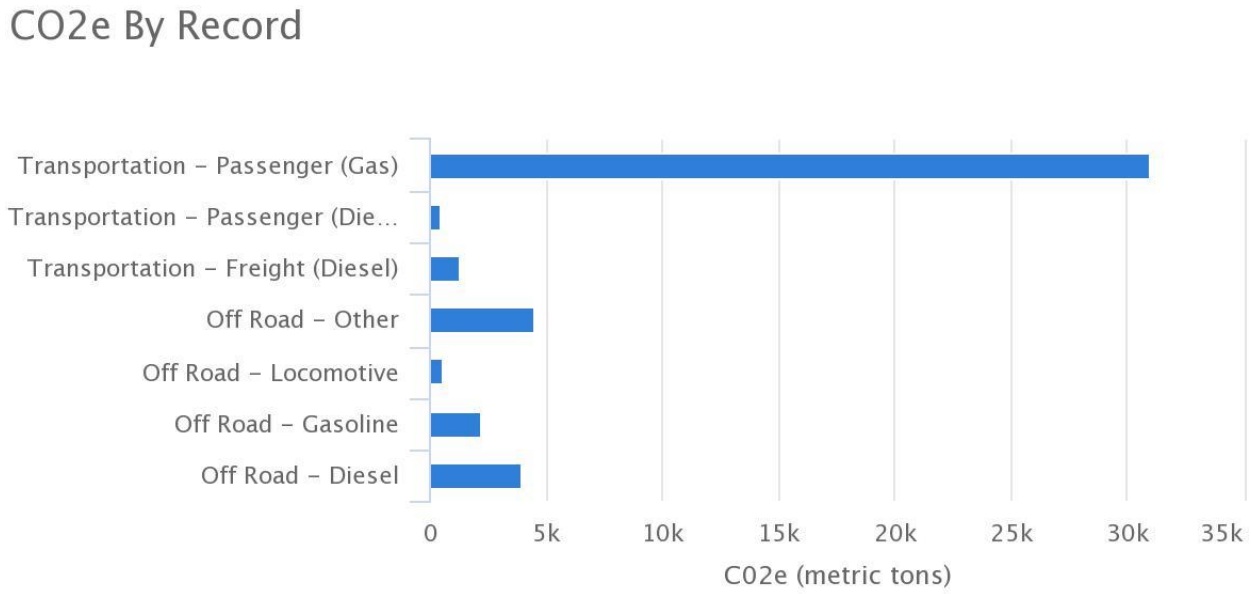
1. Passenger (Gas) - Includes motorcycles, cars, 2 axles 4 tires, and 2 axles 6 tires
2. Passenger (Diesel) - Includes busses
3. Freight (Diesel) - Includes 3 axle single unit trucks, 4 or more axle single unit trucks, 4 axle or fewer single trailers, 5 axle single trailers, 6 or more axle single trailers, 5 axle or fewer multi-trailers

A total of 83,591,985.08 miles were driven annually in the boundaries of Martinsville in 2021. By category, miles driven were 82,461,534.75 for passenger (gas), 288,979.98 for passenger (diesel), and 841,470.34 freight (diesel). This results in emissions (CO2e) of 30,975 for passenger (gas), 450 for passenger (diesel), and 1,311 freight (diesel) for total emissions of 32,736.

Additional emissions for Off-Road Transportation were calculated from the EPA's 2020 National Emissions Inventory Data tool. Emissions data was provided for the following categories by type of GHG emission: Gas, Diesel, Other, and Locomotive. Emissions by category (CO2e) were 2,182.5 for gasoline, 3,965.9 for diesel, 4,468 for other, and 532.15 for locomotive for total emissions of 11,148.55.

Total emissions for the entire transportation sector are 43,885 metric tons of CO2e.

Figure 7, Emissions from Transportation

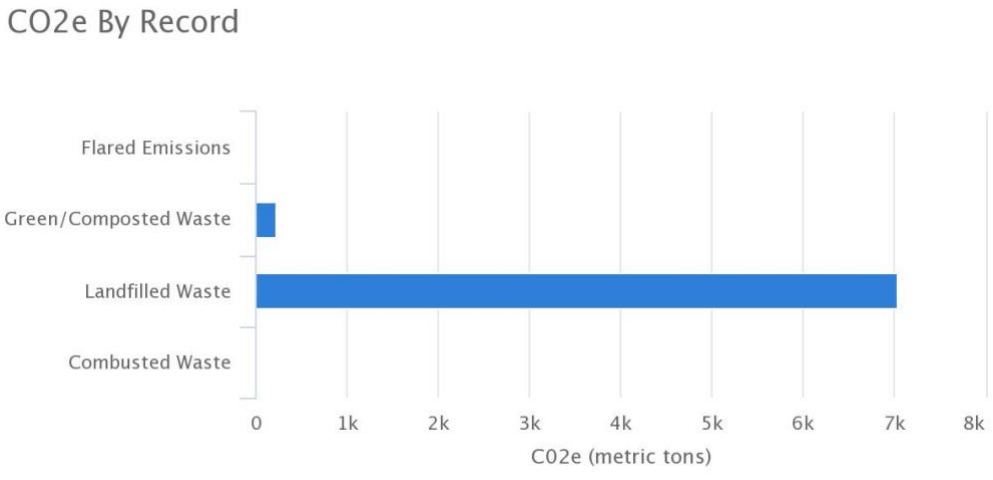


Solid Waste

Emissions from solid waste were calculated using the data supplied by Martinsville officials, which represented the raw tonnage of landfilled and composted waste. There were no reports of flared or combusted waste, meaning there is no documentation of methane (CH4) gas being captured or burned, which leaves the majority gases isolated to the landfilled waste. According to the EPA, landfills are the third largest contributor of human related methane emissions, accounting for 15.5% of human methane emissions in 2021 (EPA, 2023)

With a total of 8,978.75 tons sent to an off-site landfill in Pittsylvania County, this is classified as a Scope 3 Emission, and was calculated that this represented 120.6 MT (metric tons) of methane (CH4), which was converted to 7,034.6 MT of its carbon dioxide (CO2) equivalent. Based on the 2022 Waste Management Plan for Henry County, The City of Martinsville, and the Town of Ridgeway (LaBella Associates, 2022), it was discerned that the landfilled waste was characterized as 37.5% MSW (mixed waste), as well as 17% attributed to green waste. The green/composted waste represented a very small amount of solid waste emissions, which was calculated from 1,571.56 tons to be 6.9 MT of CH4, converted to roughly 221.52 MT of CO2e, with the EPA Greenhouse Gas Equivalencies Calculator (EPA, 2023). Figure 8 shows solid waste emissions represented in metric tons of CO2e.

Figure 8, Emissions from Solid Waste



Water and Wastewater

Emissions for water and wastewater were calculated based on data collected from Martinsville's Water Resources Department. This data contains the amount of electricity used for the calendar year 2022 (in kWh), amount of natural gas consumed (in therms), the total population within Martinsville jurisdictional boundaries served, and the total population served outside of the boundaries.

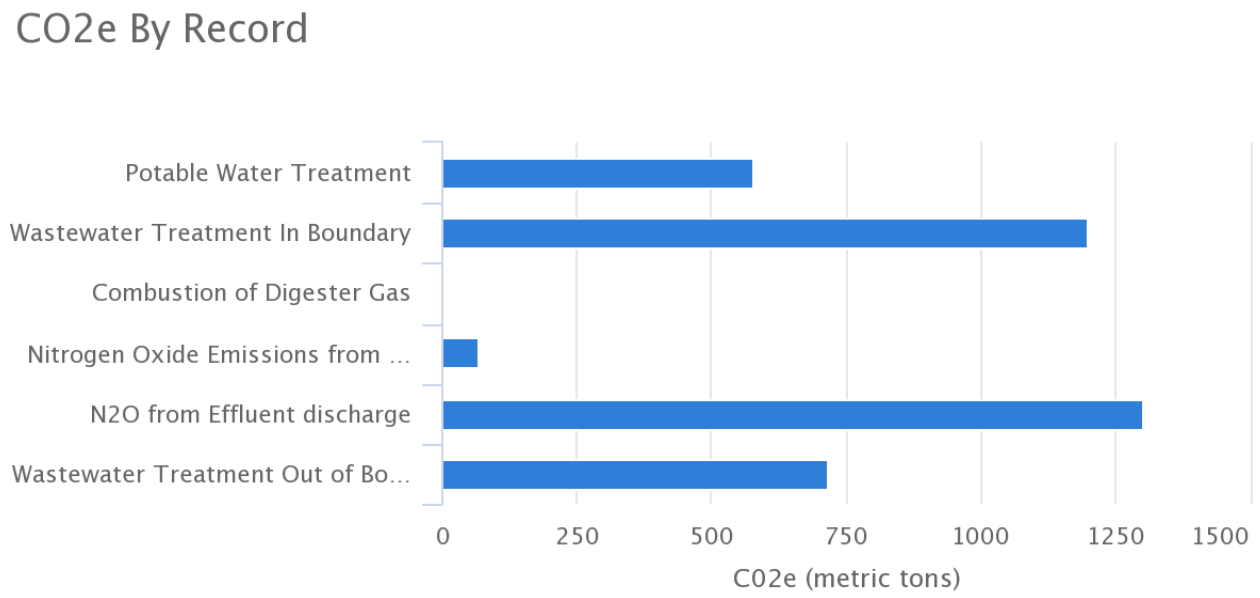
For potable water treatment in the year 2022, approximately 1,153,765 kWh of electricity was used, and 5,279 therms of natural gas. The amount of potable water delivered for residents and businesses of Martinsville was 661.774 mil. gal. The total population served by the potable water treatment plant was 14,517, of which 13,517 were in boundary. This record is important to note because it affects the scope of emissions produced by the treatment plant.

For wastewater treatment in the year 2022, approximately 3,890,400 kWh of electricity was used, and 11,209 therms of natural gas.

Per record, after converting to quantity of CO2e emissions, this breaks down to:

- Potable Water Treatment — 579 metric tons CO2e
- In boundary wastewater treatment — 1,201 metric tons CO2e
- NO_2 Emissions from wastewater treatment — 68 metric tons CO2e
- N_2O from effluent discharge — 1,302 metric tons CO2e
- Out of boundary wastewater treatment — 716 metric tons CO2e

Figure 9, Emissions from Water and Wastewater



AFOLU

AFOLU stands for Agriculture, Forestry, and Other Land Use. For Martinsville, only forestry contributes a sizable amount of greenhouse gas emissions. Forests act as greenhouse gas sinks as they absorb carbon from the atmosphere and can reduce emissions in a given area. As forests are converted to grassland, settlement, or other features, their ability to absorb carbon reduces. Emissions in this section are calculated from this reduction in carbon absorption as forests are converted or disturbed. Since forestry is a net carbon removal, data from this section is marked as information only since this inventory is only concerned with total emissions.

Emissions from forest use were calculated through the LEARN tool from ICLEI which uses a land cover

matrix and forest characteristics to estimate the annual loss or gain of forests in a specified area. Emissions for this sector total 1,678.32 metric tons of CO2e and are broken down as follows:

- Forest to Grassland - 402.8 CO2e
- Forest to Settlement - 1,033.3 CO2e
- Forest Disturbances - 192.32 CO2e
- Trees Outside Forests - 49.9 CO2e

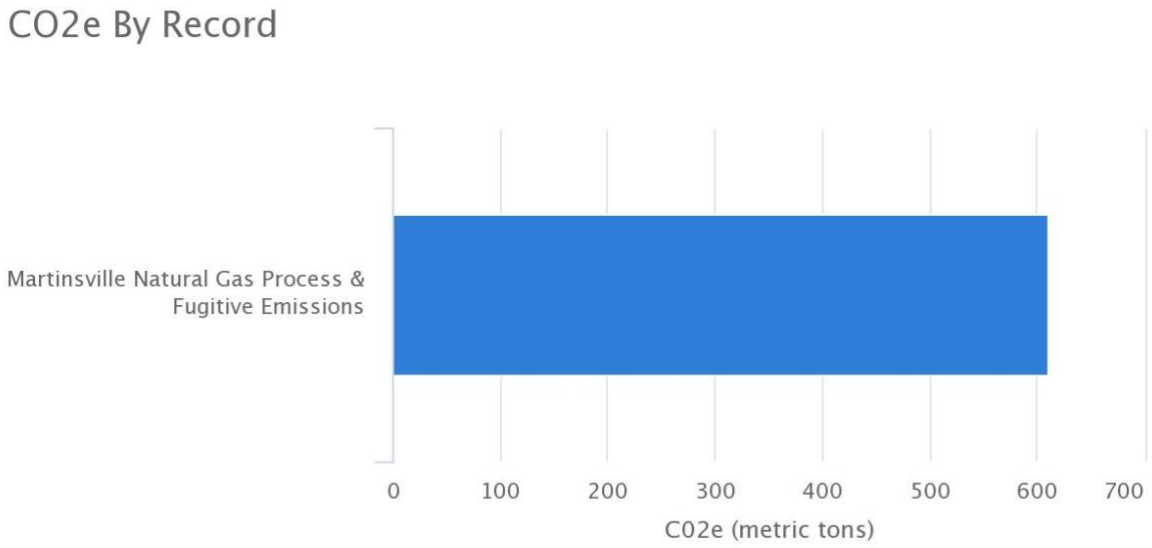
Total removals from forestry are 14,356 metric tons of CO2e and are broken down as follows:

- Undisturbed Forests - 7,348.2 CO2e
- Trees Outside Forests - 6,855.6 CO2e
- Non-Forest to Forest - 152.4 CO2e

Process and Fugitive Emissions

Process and fugitive emissions are emissions of natural gas caused by accidental losses or releases. Fugitive emissions are calculated by applying a factor (or leakage rate) to the total amount of natural gas consumed. Natural gas consumed for three sectors (commercial, industrial, and residential) for the year of 2022 was summed as 3,516,040 therms. Applying a leakage rate of 0.3% yields fugitive emissions of approximately 610 metric tons for 2022.

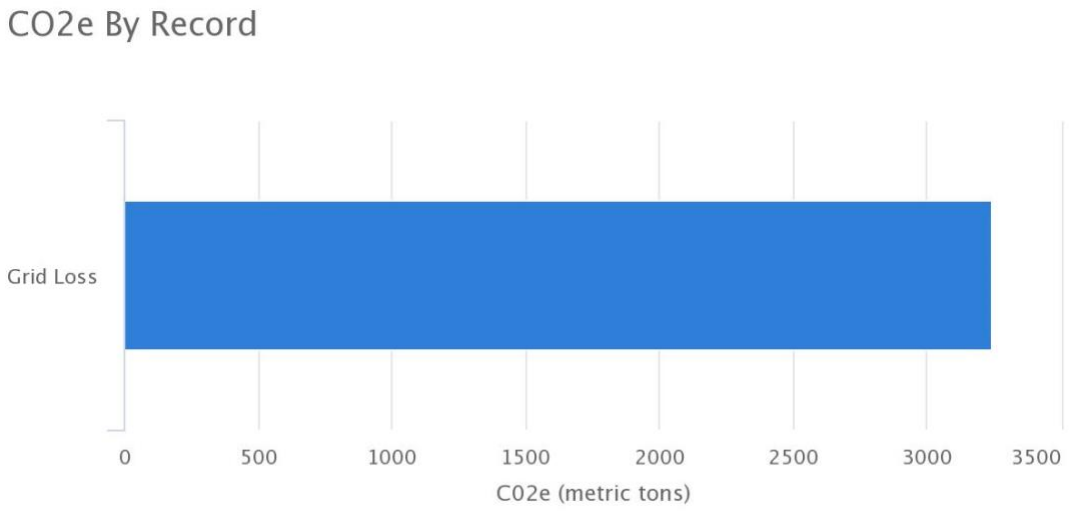
Figure 10, Emissions from Process and Fugitive Emissions



Grid Loss

Grid loss is the naturally occurring energy loss during the transmission of electricity. The Environmental Protection Agency's grid loss summary table estimates 4.5% of energy is lost in the region which contains the city of Martinsville. Using ICLEI's internal calculator, total electricity usage within the city of Martinsville of 151,018,406 kWh (Residential - 76,704,455, Commercial - 58,955,751, and Industrial - 15,358,200), and a grid loss factor of 4.5%, grid loss for Martinsville is 3,244.3 metric tons of CO2e.

Figure 11, Emissions from Grid Loss



Data Sources and References

2020 National Emissions Inventory (NEI) Data. (2020). Environmental Protection Agency. https://awsedap.epa.gov/public/single/?appid=20230c40-026d-494e-903f-3f112761a208&sheet=5d3fdda7-14bc-4284-a9bb-cfd856b9348d&opt=ctxmenu,currsel

2021 Traffic Data—Daily Vehicle Miles Traveled. (2021). Virginia Department of Transportation. https://www.virginiadot.org/info/2021_traffic_data_%E2%80%93_daily_vehicle_miles_traveled.asp

Calculate Your Carbon Footprint. (2023). The Nature Conservancy. https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator/#:~:text=A%20carbon%20footprint%20is%20the,is%20closer%20to%204%20tons.

eGRID Summary Tables 2021. (2021). Environmental Protection Agency. https://www.epa.gov/system/files/documents/2023-01/eGRID2021_summary_tables.pdf

EIA. (2023). U.S. Energy Information Administration - EIA - independent statistics and analysis. Commercial Sector Energy Consumption Estimates, Selected Years, 1960-2021, Virginia. Retrieved from https://www.eia.gov/state/seds/seds-data-complete.php?sid=VA

EPA. (2023). Retrieved from https://www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf

LaBella Associates, Solid Waste Management Plan 2022 (2022). Charlotte, NC.

Land Emissions And Removals Navigator (LEARN) tool. (2021). ICLEI. https://icleiusa.org/LEARN/

U.S. Census Bureau. "HOUSE HEATING FUEL." American Community Survey, ACS 5-Year Estimates Detailed Tables, Table B25040, 2021, . Accessed on October 25, 2023.