Fairfax County Greenhouse Gas Emissions Inventory

METHODOLOGY REPORT

This report describes the procedures used in the development of Fairfax County's community-scale greenhouse gas inventory.

March 2020

GREENHOUSE GAS EMISSION INVENTORY METHODOLOGY REPORT
Prepared for Fairfax County CECAP
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Working Draft Subject to Changes

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The Metropolitan Washington Council of Governments (COG) is an independent, nonprofit association that brings area leaders together to address major regional issues in the District of Columbia, suburban Maryland, and Northern Virginia. COG's membership is comprised of 300 elected officials from 24 local governments, the Maryland and Virginia state legislatures, and U.S. Congress.

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EXECUTIVE SUMMARY

Fairfax County recognizes that greenhouse gas (GHG) emissions from human activity are catalyzing climate change, the consequences of which pose substantial risks to the future health, wellbeing, and prosperity of our community. Furthermore, Fairfax County has multiple opportunities to benefit by acting quickly to reduce community GHG emissions, such as reducing energy and transportation costs for residents and businesses, creating green jobs, improving health of residents, making the community a more attractive place to live and locate a business.

Fairfax County has begun the climate action planning process, starting with inventorying emissions. This report provides estimates of GHG emissions resulting from activities in Fairfax County as a whole in 2018.

Key Findings

Figure ES 1: 2018 Fairfax County Community GHG Emissions

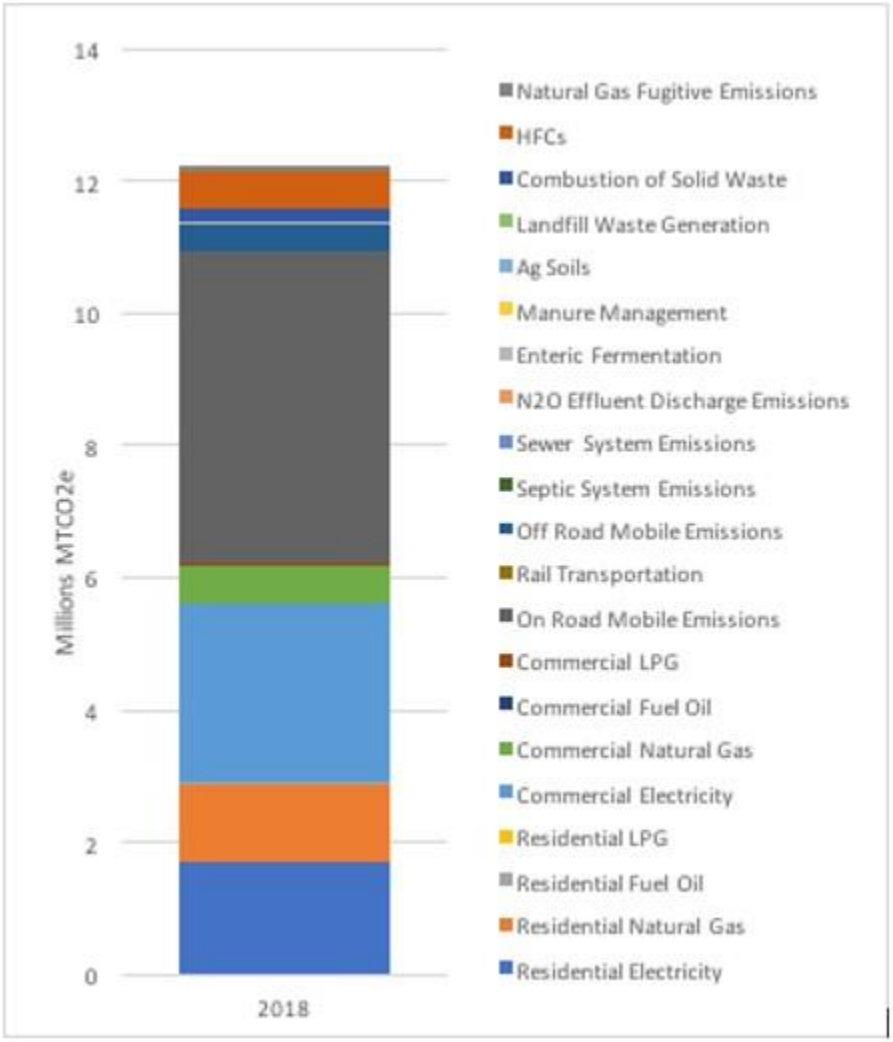

Figure ES 1 shows Fairfax County's GHG emissions for the year 2018. As you can see, largest contributor in this set is Transportation and Mobile Emissions with 42% of emissions. The next largest contributor is Commercial Energy with 27% of emissions. Residential Energy contributed 24% of emissions. Process and Fugitive Emissions, Solid Waste, Agriculture, and Wastewater Treatment were responsible for the remainder of emissions.

This inventory has been developed to be compliant with both the U.S. Communities Protocol for Accounting and Reporting Greenhouse Gas Emissions (USCP) and Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC). COG mainly follows the calculation guidance from USCP as the USCP identifies sources of data widely available to communities in the US.

COG uses reliable local data when available that provide more accurate results then the general USCP approach and calculation tool. COG inventories follow an activities-based approach, meaning emissions are calculated based on the result of an activity happening in the community. COG uses ICLEI's ClearPath tool Community Scale Inventory Module for preparing local GHG inventories, forecasts, climate action plans, and monitoring reports. The tool is consistent with both US and global accounting protocols.

INTRODUCTION TO INVENTORY METHODOLOGY

Purpose

This guide comprehensively outlines the methodologies used to carry out Fairfax County's greenhouse gas (GHG) inventory work. The ability to develop relevant, robust sets of inventories supports Fairfax County's ability to track progress towards local and regional GHG emission reduction goals and support decision-making around policies and programs that support emission reduction.

The primary purpose of this document is to outline the procedures used to complete the community-wide GHG inventory for Fairfax County. It provides context and guidance to support county staff and also provides clarity to technical staff from the county.

Methodology Basics

COG completes GHG community-scale inventories for all 24 local government members, northern Virginia, and metropolitan Washington. COG makes every effort to capture an accurate picture of GHG trends for each of its local government members, while also providing for a consistently applied methodology across all its members' communities.

COG GHG inventories strive to be compliant with both the U.S. Communities Protocol for Accounting and Reporting Greenhouse Gas Emissions (USCP) and Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC). The Protocols provide guidance on what emission types should at minimum be included in all local community GHG inventories. Additional guidance on approaches to calculating emissions are offered, but not prescribed. COG mainly follows the calculation guidance from USCP as the USCP identifies sources of data widely available to communities in the US. If COG has reliable local data available that could provide more accurate results then an alternative approach, then COG uses the local data.

COG inventories use public data readily available on a consistent basis for all its local government members. Data sources used must be available for past, current, or potential future inventories to accurately capture trends. While both accuracy and consistency are important to GHG inventories, consistency will be given a higher priority. Any models used are applied as consistently as possible. If a new version of the model is used, it is noted. Consistent Global Warming Potential Factors (GWP) are applied; COG inventories use GWP Factors from the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4).

COG inventories follow an activities-based approach, meaning emissions are calculated based on the result of an activity happening in the community.

The broad categories of emission types covered by COG's GHG inventory work include the built environment, transportation and mobile emissions, wastewater treatment, agriculture, solid waste treatment, and some process and fugitive emissions. Most of these are required elements to be compliant with the USCP and GPC. Neither require agriculture; however, it has been included here.

Emissions Types	COG Inventory	USCP Required	GPC Required
Built Environment	√	√	√
Transportation and Mobile	√	√	√
Wastewater Treatment	√	√	√
Agriculture	√	X	X
Solid Waste Treatment	√	√	√
Some Process and Fugitive	√	X	√

These emission types are further broken down into 16 emissions activities and 22 separate inventory records that are calculated and added together to get total emissions by type and overall emissions. The gases calculated within these inventory records include carbon dioxide (CO2), methane (CH4), Nitrous oxide (N2O), Hydrofluorocarbons (HFCs), and Perfluorocarbons (PFCs).

See Appendix A to review a detailed table of the emission types, activities calculated, GHGs and methodologies covered, and data confidence levels.

One area in which the COG inventories are not compliant with the Protocols is that the USCP requires identifying how much of commercial energy consumption is attributable to providing water supply and wastewater services. COG will continue to work with the drinking water and wastewater utilities to incorporate it into future inventories.

Process

Stakeholder Engagement

COG continues to work with its local government members to capture as accurate of a picture as possible for each community while providing consistent data inputs and methodologies across all communities. In order to accomplish this, COG staff help members understand the existing process and methodologies, provide opportunities for their input on methodologies and the products, and support them on how they want to communicate results to their communities.

ClearPath

ICLEI's ClearPath tool is an online tool for preparing local GHG inventories, forecasts, climate action plans, and monitoring reports. The tool is consistent with both US and global accounting protocols. COG uses the Community Scale Inventory Module to support completing its GHG inventory work for its members and the region.

COG created inventory records in ClearPath for all emission activities in the inventory for Fairfax County. Some of the tool's calculators are used to calculate emissions as inventory records are created, while in other instances, previously calculated emissions are recorded in the inventory record.

GETTING STARTED

Setting Up the Greenhouse Gas Inventory

First Things First

DESCRIPTION

Gathering demographic and economic data was the first step taken in Fairfax County's inventory. Some of the demographic and economic data is used to estimate GHG emissions. For instance, household and commercial building data is used to estimate non-utility fuel consumption, such as fuel oil. Also, population data may serve as a means to downscale to a local community when local data is unavailable.

The demographic and economic data are also used as a benchmark throughout the inventory to gauge emissions per person, household, employee, etc. Therefore, it is important to gather this information at the start of the inventory process and use it as consistently as possible across all emissions activity calculations.

DATA COLLECTION

American Community Survey has data readily available for all COG member local governments. This data is used as much as possible for calculations and benchmarks throughout the inventory. However, COG transportation and wastewater models use COG Cooperative Forecast data; therefore, transportation on-road and off-road and all wastewater calculations use the Cooperative Forecast data for its benchmarking.

In addition, COG uses CoStar, a commercial building database for metropolitan regions, to track commercial construction in the region. It also provides readily available data for the GHG inventories. Gross Domestic Product data is an input to provide during the creation of an inventory in ClearPath.

BUILT ENVIRONMENT

Residential Energy

Emissions from Grid Electricity

Residential Electricity

DESCRIPTION
Residential Electricity accounts for emissions resulting in electricity use in residential buildings. Energy use in buildings account for a significant portion of greenhouse gas (GHG) emissions. According to the U.S. Communities Protocol (USCP), local jurisdictions can often influence electricity use through building codes, incentives, and technical assistance.

METHODOLOGY
The Residential Electricity emission calculations follow the U.S. Communities Protocol recommended methodology as outlined in Appendix C, BE.2.1 from Version 1.1 of the Protocol.

DATA COLLECTION
COG annually collects aggregated account and consumption data from the 7 electric utilities that serve metropolitan Washington. For Fairfax County, electric utility data was collected from Dominion Energy and NOVEC.

Data Used:

- Accounts: Number of residential electric accounts from all utilities serving Fairfax County.
- Consumption: Annual residential electricity use in kilowatt hours from all utilities serving Fairfax County.
- eGRID: U.S. Environmental Protection Agency (EPA) eGRID Subregion Output Emission Rates – Greenhouse Gases. Subregion SERV Virginia/Carolina (SRVC) total output emission rates of CO_2 (lb/MWh), CH_4 (lb/GWh), and N_2O (lb/GWh).

Emissions from Stationary Fuel

Residential Natural Gas

DESCRIPTION
Residential Natural Gas consumption accounts for combustion emissions from stationary fuel applications, such as furnaces. Energy use in buildings account for a significant portion of greenhouse gas (GHG) emissions. According to the U.S. Communities Protocol (USCP), local jurisdictions can often influence natural gas use through building codes, incentives, and technical assistance.

METHODOLOGY
The Residential Natural Gas emission calculations generally follow the U.S. Communities Protocol recommended methodology as outlined in Appendix C, BE.1.1 from Version 1.1 of the Protocol.

DATA COLLECTION

COG annually collects aggregated account and consumption data from the 3 natural gas utilities that serve metropolitan Washington. For Fairfax County, natural gas utility data was collected from Columbia Gas and Washington Gas.

Data Used:

- Accounts: Number of residential natural gas accounts from all utilities serving Fairfax County.
- Consumption: Annual residential consumption of natural gas in Therms from all utilities serving Fairfax County.

Residential Fuel Oil

DESCRIPTION
Residential Fuel Oil accounts for both distillate fuel oils and kerosene used in stationary applications. Energy use in buildings account for a significant portion of greenhouse gas (GHG) emissions. According to the U.S. Communities Protocol (USCP), local jurisdictions can often influence fuel oil use through building codes, incentives, and technical assistance.

Distillate fuel oils are further classified by level of volatility, listed from least to greatest (No. 1, No. 2, and No. 4). Residential fuel oils are less volatile than gasoline and are burned for space heating or water heating by private household consumers. No.2 fuel oil (Heating Oil) is the most common type used by households for the specific purpose of heating their home, water heating, cooking, etc., excluding farm houses, farming, and apartment buildings. No. 1 fuel oil is used by households mainly for portable outdoor stoves, portable outdoor heaters, and some residential space heating. Kerosene is a distilled product of oil or coal with the generic name kerosene, having properties like those of No. 1 fuel oil.

METHODOLOGY
The Residential Fuel Oil emission calculations follows the U.S. Communities Protocol recommended methodology as outlined in Appendix C, BE.1.2 from Version 1.1 of the Protocol. This methodology estimates residential fuel oil consumption in gallons (including distillate fuel oil and kerosene) by estimating per household consumption in VA and multiplying that by the estimated number of households using fuel oil as a home heating fuel in Fairfax County. Gallons are used to estimate emissions.

DATA COLLECTION
Local data on households and consumption related to fuel oil is not readily available for all COG members. However, the Energy Information Administration (EIA) has readily available data on state-wide fuel oil consumption and the American Community Survey (ACS) has readily available data on number of households using fuel oil as a home heating fuel.

Data Used:

- Households using Fuel Oil: Number of households using fuel oil data for Fairfax County collected from the ACS' Selected Housing Characteristics.
- Statewide Residential Fuel Oil Consumption: EIA State Energy Data System (SEDs) data for Statewide Residential Distillate Fuel Oil and Kerosene consumption in thousands of barrels ('000 Barrels).

Notes on Data:

- No.4 Fuel Oil is not included in residential fuel oil calculations because it is a blended mixture composed of distillate fuel oil and residual fuel oil stocks used extensively in industrial plants and commercial burner installations not equipped with preheating facilities.
- Beginning with the 2015 RECS, kerosene is included with fuel oil because kerosene use is relatively rare for households.
- ACS identifies the number of housing units using "kerosene, fuel oil, etc." This category includes fuel oil, kerosene, gasoline, alcohol, and other combustible liquids. In our calculations, we assume that values for other types of fuel oil beside kerosene and heating oil are marginal.

Residential LPG

DESCRIPTION

Liquefied Petroleum Gas (LPG) refers to a group of hydrocarbon gases derived from crude oil refining or natural gas processing. Propane is the most common LPG. In the U.S. and Canada, commercially available propane (LPG) is not totally pure; its typically at least 90% propane, with the rest being ethane, propylene, butane, and odorants including ethyl mercaptan. LPGs are used as fuel in heating appliances, cooking equipment, and vehicles. It is usually delivered by tank trucks and stored near a housing unit in a tank or cylinder until used; however, propane stored in canisters can also be purchased from retail stores. For our purposes, LPG's are equated with propane, yet propane also encompasses similar fuel gases, such as butane, supplied to a residence in liquid form. According to the U.S. Communities Protocol (USCP), local jurisdictions can often influence propane use through building codes, incentives, and technical assistance.

METHODOLOGY

The Residential LPG emission calculations follows the U.S. Communities Protocol recommended methodology as outlined in Appendix C, BE.1.2 from Version 1.1 of the Protocol. This methodology estimates residential LPG consumption in gallons by estimating per household consumption in VA and multiplying that by the estimated number of households using fuel oil as a home heating fuel in Fairfax County. Gallons are used to estimate emissions.

DATA COLLECTION

Local data on households and consumption related to fuel oil is not readily available for all COG members. However, the EIA has readily available data on state-wide fuel oil consumption and the American Community Survey (ACS) has readily available data on number of households using fuel oil as a home heating fuel.

Data Used:

- Households using LPG: Number of households using LPG data for Fairfax County collected from the American Community Survey's Selected Housing Characteristics.
- Statewide Residential LPG Consumption: EIA State Energy Data System (SEDs) data for Statewide Residential LPG consumption in thousands of barrels ('000 Barrels).

Data Notes:

- The ACS identifies the number of homes using "bottled, tank, or LP gas." This category includes liquid propane gas stored in bottles or tanks that are refilled or exchanged when empty.

Commercial Energy

Emissions from Grid Electricity

Commercial Electricity

DESCRIPTION
Commercial Electricity accounts for emissions resulting in electricity use in commercial, government, industrial, and other non-residential buildings and facilities. Energy use in buildings account for a significant portion of greenhouse gas (GHG) emissions. According to the U.S. Communities Protocol (USCP), local jurisdictions can often influence electricity use through building codes, incentives, and technical assistance.

METHODOLOGY
The Commercial Electricity emission calculations follow the USCP recommended methodology as outlined in Appendix C, BE.2.1 from Version 1.1 of the Protocol. Consumption data and the U.S. EPA eGRID emission data are factored into the emission estimates calculated in ClearPath.

DATA COLLECTION
COG annually collects aggregated account and consumption data from the 7 electric utilities that serve metropolitan Washington. For Fairfax County, electric utility data was collected from Dominion Energy and NOVEC.

Data Used:

- Accounts: Number of commercial, governmental, and industrial electric accounts from all utilities serving Fairfax County.
- Consumption: Annual commercial, governmental, and industrial electricity consumption in kilowatt hours from all utilities serving Fairfax County.
- eGRID: U.S. Environmental Protection Agency (EPA) eGRID Subregion Output Emission Rates – Greenhouse Gases. Subregion SERV Virginia/Carolina (SRVC) total output emission rates of CO_2 (lb/MWh), CH_4 (lb/GWh), and N2O (lb/GWh).

Emissions from Stationary Fuel

Commercial Natural Gas

DESCRIPTION
Natural gas consumption in the non-residential setting produces combustion emissions from stationary applications, such as boilers and furnaces. Energy use in buildings account for a significant portion of greenhouse gas (GHG) emissions. According to the U.S. Communities Protocol (USCP), local jurisdictions can often influence natural gas use through building codes, incentives, and technical assistance.

METHODOLOGY
The Commercial natural gas emission calculations generally follow the U.S. Communities Protocol recommended methodology as outlined in Appendix C, BE.1.1 from Version 1.1 of the Protocol.

DATA COLLECTION
COG annually collects aggregated account and consumption data from the 3 natural utilities that serve metropolitan Washington. For Fairfax County, natural gas utility data was collected from Columbia Gas and Washington Gas.

Data Used:

- Accounts: Number of commercial natural gas accounts from all utilities serving Fairfax County.
- Consumption: Annual commercial consumption of natural gas in Therms from all utilities serving Fairfax County.

Commercial Fuel Oil

DESCRIPTION
Commercial Fuel Oil refers to a liquid petroleum product used as an energy source that is less volatile than gasoline. Commercial Fuel Oil is comprised of distillate fuels (No. 1, 2 and 4), residual fuels (No.5 and 6) and kerosene (No. 1). Distillate fuel oils represent the lighter petroleum fractions produced in conventional distillation processes that include both fuel oils and diesel fuels that are further classified by level of volatility, listed from least to greatest (No. 1, No. 2, and No. 4). Products known as No. 1, No. 2, and No. 4 fuel oils are lighter oils primarily used for space heating and electric power generation. Residual fuels are generally classified as heavier oils, known as No. 5 and No. 6 fuel oils, that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations. Kerosene is a light petroleum distillate with properties like those of No. 1 fuel oil; primarily used in space heaters, cook stoves, and water heaters and is suitable for use as a light source when burned in wick-fed lamps.

METHODOLOGY
The Commercial Fuel Oil emission calculations follows the U.S. Communities Protocol recommended methodology as outlined in Appendix C, BE.1.3 from Version 1.1 of the Protocol, with one exception. This methodology calculates percent of square footage using fuel oil instead of percent of number of buildings using fuel oil.

Values for commercial building square footage using Fuel Oil were scaled locally by multiplying the local jurisdictional commercial square footage by the percentage of commercial building square footage using Fuel Oil in the broader South Atlantic Region. These values, in turn, were multiplied by the fuel energy intensity in gallons per square foot (gallons/ft.^{2}) to get total Fuel Oil consumption per locality and region. Consumption was converted to emissions in ClearPath.

DATA COLLECTION
The number of commercial buildings and total square footage for Fairfax County is readily available from the 2015 CoStar Commercial Property Records. Data is not readily available on stationary fuel use for these buildings. The Energy Information Administration (EIA) does have data available for larger regions on total commercial buildings and square footage; number and square footage of buildings using Fuel Oil; and energy intensity. EIA's South Atlantic Region in the Commercial Building Energy Consumption Survey (CBECS) includes DC, MD, VA, DE, WV, NC, SC, GA, and FL.

Data Used:

- Commercial buildings and total square footage: Data for Fairfax County are collected from the CoStar Commercial Property Records. This database is available via subscription by COG's Department of Community Planning and Services Department (CPS).

- Total Commercial Floorspace and Commercial Square Footage using Fuel Oil: Values for the South Atlantic Region (most specific region) were derived from the EIA CBECS.
- Fuel Oil Energy Intensity: A value for the South Atlantic Region was derived directly from the EIA CBECS.

Notes on Data:

- CoStar:
    - The Commercial Construction Inventory focuses on "non-residential" projects that have been completed in metropolitan Washington. These include office, retail, industrial, flex, healthcare, religious, educational, utility, and some government properties and other projects that develop employment space, and in many cases, include associated parking structures. The inventory is limited to projects that create new or additional space. COG staff compiled this report by analyzing commercial property records from the CoStar subscription database.
    - All buildings are classified by their majority use. Therefore, a building with 100% office space will be indistinguishable in the database from one with 51 percent office space and 49 percent retail or other use.
    - Flex buildings are: "A type of building(s) designed to be versatile, which may be used in combination with office (corporate headquarters), research and development, quasi-retail sales, and including but not limited to industrial, warehouse, and distribution uses. At least half of the rentable area of the building must be used as office space. Flex buildings typically have ceiling heights under 18', with light industrial zoning. Flex buildings have also been called Incubator, Tech and Showroom buildings in markets throughout the country."
    - CoStar groups industrial buildings like distribution, warehouses and data centers with Flex space interchangeably, as those classes of buildings have been included in both categories. However, Flex space is more likely to include some office and retail uses, so for the GHG inventory, flex and industrial classes are lumped together.
    - Multi-family buildings (includes only rental buildings, not condos and co-ops) have been omitted from this section of the CoStar data.
- EIA CBECS:
    - A building in the CBECS constitutes "a structure totally enclosed by walls extending from the foundation to the roof, containing over 1,000 square feet of floorspace and intended for human occupancy. Included in the survey as a specific exception were structures erected on pillars to elevate the first fully enclosed level but leaving the sides at ground level open. Excluded from the survey as non-buildings were the following: structures (other than the exception just noted) that were not totally enclosed by walls and a roof (such as oil refineries, steel mills, and water towers), street lights, pumps, billboards, bridges, swimming pools, oil storage tanks, construction sites, and mobile homes and trailers, even if they housed commercial activity. Since 1995, the CBECS has excluded enclosed parking garages and commercial buildings on manufacturing sites".

Commercial LPG

DESCRIPTION

Liquefied Petroleum Gas (LPG) refers to a group of hydrocarbon gases derived from crude oil refining or natural gas processing. Propane is the most common LPG. In the U.S. and Canada, commercially

available propane (LPG) is not totally pure; its typically at least 90% propane, with the rest being ethane, propylene, butane, and odorants including ethyl mercaptan.

METHODOLOGY

In this methodology, any LPG reported was assumed to be propane. The Commercial LPG emission calculations follows the U.S. Communities Protocol recommended methodology as outlined in Appendix C, BE.1.3 from Version 1.1 of the Protocol. This methodology calculates percent of square footage using fuel oil instead of percent of buildings using fuel oil.

Values for commercial building square footage using LPG were scaled locally by multiplying the local jurisdictional commercial square footage by the percentage of commercial building square footage using LPG in the broader South Atlantic Region. These values, in turn, were multiplied by the fuel energy intensity in gallons per square foot (gallons/ft.^{2}) to get total LPG consumption per locality and region. Consumption was converted to emissions in ClearPath.

DATA COLLECTION

The number of commercial buildings and total square footage for Fairfax County is readily available from the 2015 CoStar Commercial Property Records. There is not data readily available on stationary fuel use for these buildings. The Energy Information Administration (EIA) does have data available on total commercial buildings and square footage or larger regions; number and square footage of buildings using LPG; and energy intensity. EIA's South Atlantic Region in the Commercial Building Energy Consumption Survey (CBECS) includes DC, MD, VA, DE, WV, NC, SC, GA, and FL.

Data Used:

- Commercial buildings and total square footage: Data for Fairfax County are collected from the CoStar Commercial Property Records. This database is available via subscription by COG's Department of Community Planning and Services Department (CPS).
- Total Commercial Floorspace and Commercial Square Footage using LPG: Values for the South Atlantic Region (most specific region) were derived from the EIA CBECS.
- LPG Energy Intensity: A value for the South Atlantic Region was derived directly from the EIA CBECS.

Notes on Data:

- See notes from Commercial Fuel Oil

TRANSPORTATION AND MOBILE EMISSIONS

Transportation and Mobile Emissions

On Road Transportation

On Road Mobile Emissions

DESCRIPTION
On Road Mobile Emissions represent exhaust and evaporative emissions of carbon dioxide (CO2), nitrous oxide (N2O), and methane (CH4) from on road passenger and freight motor vehicles. On Road mobile emissions account for approximately 39% of Fairfax County's greenhouse gas emissions. On Road emissions can be influenced by local governments through land use and urban design decisions and transportation infrastructure investments. Advancing electrification of the transportation system, overall improvement of fuel economy, and increasing alternative trip modes play a particularly important role in reducing on road emissions.

METHODOLOGY
The On Road Transportation emission calculations generally follows the U.S. Communities Protocol recommended methodology as outlined in Appendix D, TR.1.A from Version 1.1 of the Protocol.

COG Department of Transportation Planning (DTP) staff prepare estimated greenhouse gas emissions (GHG) and modeled vehicle miles traveled (VMT) data based on planning assumptions including the Transportation Planning Board's (TPB) Constrained Long Range Plan (CLRP), COG Cooperative Forecasts (demographic data), and vehicle registration (VIN) data, and modeling tools including the TPB's travel demand model and the Environmental Protection Agency's (EPA) mobile emissions model.

Data for 2018 was based on the Visualize 2045 Long-Range Transportation Plan (adopted in October 2018 by the Transportation Planning Board), Round 9.1 Cooperative Forecasts, 2016 VIN data, Version 2.3.75 travel demand model, and MOVES2014b mobile emissions model.

DTP staff provide GHG emissions estimates from EPA's mobile emission model for the Virginia counties. The data are provided in both short tons and metric tons. MOVES outputs use Global Warming Potential (GWP) Factors from the Intergovernmental Panel on Climate Change Second Assessment Report (IPCC AR2). Therefore, the MOVES outputs are converted by DEP staff to metric tons and CO_2 equivalents using GWP Factors from IPCC's Fourth Assessment Report (AR4).

DATA COLLECTION
DTP staff provide GHG emissions estimates by state, jurisdiction, and vehicle type. Emissions are based on both travel and non-travel related inputs to the MOVES model. Exhibit 10 on page 13 of the Air Quality Conformity Analysis of the 2016 CLRP Amendment and the FY 2017-2022 TIP provides more information on inputs to the MOVES model. Vehicle types are: passenger cars, passenger trucks, motorcycles, school buses, transit buses, intercity buses, refuse trucks, light commercial trucks, motor homes, single unit short-haul trucks, single-unit long-haul truck, combination short-haul trucks, and combination long-haul trucks.

It is important to note that the modeled jurisdiction-level vehicle VMT input to the model is based on the travel occurring on the roadways in each jurisdiction, regardless of where the trips originate and terminate.

Data is provided by DTP staff for the TPB's Planning Area for Fairfax County (including Fairfax City and City of Falls Church).

Data Used:

- Population: Population data for Fairfax County, as well as U.S. totals, are collected from COG's Cooperative Forecasts and the American Community Survey.
- Emissions: Emissions in short tons of Atmospheric Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O) from the EPA mobile emissions model is obtained from DTP staff.
- Vehicle Miles Travelled: Modeled VMT data by jurisdiction is obtained from DTP staff. This is not used to further calculate emissions; however, it is used as an indicator/benchmark to support local jurisdictions in their understanding of resultant emissions.

Rail Transportation

Rail Transportation

DESCRIPTION

Rail Transportation calculates emissions resulting from MARC and Virginia Railway Express (VRE) trains carrying commuters from Maryland and Virginia. Combined average weekday ridership is approximately 60,000 passengers. These commuter rail services serve an important role in providing for a balanced intermodal transit for metropolitan Washington. Local jurisdictions may have influence on service levels in its community via supportive land use policies, infrastructure investments, and connecting transit services.

METHODOLOGY

The Commuter Rail Transportation emission calculations generally follow the USCP recommended methodology as outlined in Appendix D, TR.4 from Version 1.1 of the Protocol. In this approach, emissions are calculated from annual diesel consumption of commuter rail operators.

Maryland Transit Administration (MTA) and VRE reports diesel consumption for their full commuter rail operations, some of which occurs outside of metropolitan Washington. MTA and VRE annual diesel consumption are attributed to the region by the percent of stations located in the region – 59% of MTA's MARC stations and 75% of VRE stations are located in the region. Emissions for local jurisdictions are further downscaled by population. No commuter rail emissions are attributed to the District of Columbia.

DATA COLLECTION

Diesel consumption of commuter rail systems (code CR) is readily available via the Federal Transit Administration's (FTA) National Transit Database. Data is downscaled by station locations and population because there is no readily available, consistent data for VRE commuter rail passenger travel activity.

Data Used:

- Population: Population data for Fairfax County, as well as U.S. totals, are collected from the American Community Survey.

- Diesel Consumption: Annual diesel consumption in gallons and annual locomotive miles traveled for VRE as reported to the FTA National Transit Database.

Emissions from Off Road Vehicles

Off Road Mobile Emissions

DESCRIPTION
Off Road Mobile Emissions account for nonroad equipment using gasoline, diesel, compressed natural gas and liquefied petroleum gas. Nonroad mobile sources are broken up into the following categories:

- Lawn and garden equipment
- Light commercial equipment
- Industrial equipment
- Construction equipment
- Agricultural or farm equipment
- Recreational land vehicles or equipment
- Railroad maintenance equipment

While off road emissions account for a small percent of the overall GHG emissions, emissions are increasing across metropolitan Washington due to limited control measures.

METHODOLOGY
The Off Road Transportation emission calculations generally follow the U.S. Communities Protocol recommended methodology as outlined in Appendix D, TR.1.8 from Version 1.1 of the Protocol.

EPA's Motor Vehicle Emissions Simulator (MOVES2014b) was used to estimate greenhouse gas emissions from nonroad engines and equipment except for commercial marine vessels, railroads, and aircrafts. The MOVES2014b model calculates past, present, and future emission inventories (i.e., tons of pollutant) for these sources. Off Road emissions data for Atmospheric Carbon Dioxide (CO_2) and Methane (CH_4) are pulled from the model for the inventory year. MOVES outputs are in short tons and use Global Warming Potential (GWP) Factors from the Intergovernmental Panel on Climate Change Second Assessment Report (IPCC AR2). Therefore, the MOVES outputs need to be converted to metric tons and the CO_2 equivalents need to be updated using GWP Factors from IPCC's Fourth Assessment Report (AR4).

Off Road categories excluded from the MOVES2014b model include large commercial marine, passenger and freight locomotives, and aircraft. Metropolitan Washington does not have a large marine port, so excluding large commercial marine vessels is not a concern for the purposes of COG's GHG inventory work. Emissions from locomotives and aircraft are however included in separate calculations above.

DATA COLLECTION
The MOVES 2014b model data outputs are available for Fairfax County.

Data Used:

- Population: Population data for Fairfax County, as well as U.S. totals, are collected from COG Cooperative Forecasts and the American Community Survey.

- Emissions: Emissions in short tons of Atmospheric Carbon Dioxide (CO_2) and Methane (CH_4) from the EPA MOVES 2014b Model is obtained from COG Department of Environment's Air Quality Program.

WASTEWATER TREATMENT

Water and Wastewater

Fugitive Emissions from Septic Systems

Septic System Emissions

DESCRIPTION
Septic Systems Emissions account for the fugitive emissions resulting from the physical settling and biologic activity during the treatment process in septic tanks. According to the U.S. Communities Protocol (USCP), local governments can influence community septic through local building codes, providing and promoting incentives, etc.

METHODOLOGY
The Fugitive Emissions from Septic Systems calculations follow the U.S. Communities Protocol recommended methodology as outlined in Appendix F.WW.11 from Version 1.1 of the Protocol. The methodology estimates GHG emissions based on the population served by septic.

To estimate population served by septic, COG runs the Regional Wastewater Flow Forecast Model (RWFFM) to estimate population served by sewer and wastewater treatment plants (WWTPs) in Fairfax County. COG's Wastewater Team works closely with utilities and annually collects plant-level data to feed the RCFFM. Total population subtracted from the population served by sewer provides an estimate of the population served by septic.

DATA COLLECTION
The RWFFM is processed by COG staff and provides data that is available to use for the purposes of the GHG inventories. COG Cooperative Forecasts are used for population estimates in the FWFFM.

Data Used:

- Data retrieved from RWFFM developed by COG Department of Environmental Programs Wastewater Modeler.

Notes on Data:

- Although data can be calculated to show the number of septic systems by county, population served by those systems are not readily available. Although this methodology is using data that aligns with the robust RWFFM, population served by septic could be estimated based on the average number of people per household. COG staff has spot checked the septic results using this approach.

Nitrification/Dentrification Process N_2O Emissions from Wastewater

Sewer System Emissions

DESCRIPTION

This calculation of Sewer System Emissions accounts for N_2O emissions during the treatment process at wastewater treatment plants (WWTPs). All WWTPs in the region operate with nitrification (converting ammonia to nitrate) and denitrification (converting nitrate into nitrogen gas) processes to remove nutrients from wastewater. This process protects the water quality of local waterways. In 2015, more than 90% of the population in the region was being served by a WWTP.

According to the U.S. Community Protocol (USCP), wastewater utilities can potentially offset GHG emissions through renewable energy generation from biogas and/or biosolids, using reclaimed water to displace imported water, or producing biosolids as fertilizer for use.

METHODOLOGY
The Nitrification/Denitrification Process N_2O Emissions from Wastewater Treatment calculations follow the U.S. Communities Protocol recommended methodology as outlined in Appendix F.WW.7 from Version 1.1 of the Protocol. The methodology estimates GHG emissions based on the population served by sewer.

Population served by sewer is estimated via a robust Regional Wastewater Flow Forecast Model (RWFFM). Outputs include population served by sewer by wastewater treatment plant (WWTP). COG's Wastewater Team works closely with utilities and annually collects plant-level data to feed the RWFFM.

DATA COLLECTION
The RWFFM is processed annually by COG staff and outputs data that is available to use for the purposes of the GHG inventories. COG Cooperative Forecasts are used for population estimates.

Data Used:

- Population served by sewer: Data retrieved from RWFFM developed by COG Department of Environmental Programs Wastewater Team.

Process N_2O from Effluent Discharge to Rivers and Estuaries

N_2O Effluent Discharge Emissions

DESCRIPTION
N_2O Effluent Discharge Emissions account for the emissions resulting from treated wastewater that flows out of a treatment facility and discharged into waterways. Most of the nitrogen content is removed in the treatment process; however, when effluent containing nitrogen reaches the natural watershed a reaction occurs that releases N_2O emissions. This reaction makes up the vast majority of N_2O generated from a wastewater treatment plan (WWTP).

METHODOLOGY
The Process N_2O from Effluent Discharge to Rivers and Estuaries calculations follow the U.S. Communities Protocol recommended methodology as outlined in Appendix F.WW.12 from Version 1.1 of the Protocol. The methodology estimates GHG emissions based on the population served by sewer and daily Nitrogen loads.

Population served by sewer are estimated via a robust Regional Wastewater Flow Forecast Model (RWFFM). Outputs include population served by sewer by WWTP. Data inputs on Nitrogen loads are collected for each WWTP. The modeling helps translate loads to jurisdictions, such as Fairfax County,

that are served by multiple WWTPs. COG's Wastewater Team annually collects plant-level data from utilities and the Chesapeake Bay Program DataHub to feed the RWFFM.

DATA COLLECTION

The RWFFM is processed by COG staff and outputs data that is available to use for the purposes of the GHG inventories. COG Cooperative Forecasts are used for population estimates.

Data Needs:

- Population served by sewer: Data is retrieved from the RWFFM developed by COG Department of Environmental Programs Wastewater Team.
- Daily Nitrogen Load: Values in kg N/day are retrieved from the RWFFM developed by COG Department of Environmental Programs Wastewater Team.

AGRICULTURE

Agriculture

Emissions from Agricultural Activities

Enteric Fermentation

DESCRIPTION
Enteric Fermentation accounts for the methane produced from animal digestion in cows, sheep, goats, swine, and horses. According the U.S. Communities Protocol (USCP), enteric fermentation accounts for 25% of nationwide methane emissions from anthropogenic activities. The U.S. EPA report titled 'User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool' states that a higher quality of feed produces lower emissions from these animals.

METHODOLOGY
The U.S. EPA's Emission Inventory Improvement Program developed a series of Excel-based State GHG Inventory Tools, which include an Agriculture Module. The Ag Module calculates methane (CH_4) and nitrous oxide (N_2O) emissions from the agricultural sources. Agricultural sources and activities relevant to Fairfax County were calculated using this tool including Enteric Fermentation, Manure Management, and Ag Soils. The module takes data inputs and applies state-specific data and factors to calculate emissions. The methodologies applied in the tool are generally consistent with EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks.

The USCP does offer similar suggested calculations for enteric fermentation and manure management, where national default factors are applied. While Ag emissions calculated offline can be documented in ClearPath, it does not currently offer a calculator that estimates emissions. At this time, EPA's State Inventory Tool offers the most streamlined calculation process with the most locally relevant default factors for COG's GHG inventory work.

DATA COLLECTION
Metropolitan Washington data inputs into EPA's State GHG Inventory Tool are pulled at the county-scale from the EPA Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST). CAST is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning.

Data Used:

- Livestock: Livestock population ('000 head) for dairy cows, beef cattle, sheep, goats, swine, horses derived from the Chesapeake Assessment Scenario Tool.

Notes on Data:

- The CAST model output for Livestock is the Animal Count. It will have to be converted to '000 head to enter into the EPA State Inventory Tool, Ag Module.
- Agricultural data is based on the U.S. Department of Agriculture's AG Census. The AG Census is conducted every 5 years and CAST interpolates data to estimate annual data.

Manure Management

DESCRIPTION
Manure Management accounts for emissions from management systems that stabilize or store livestock manure. It accounts for manure from dairy cows, beef cattle, sheep, goats, swine, horses and poultry operations. Methane (CH_4) is a natural by-product of manure decomposition and nitrous oxide (N_2O) is also produced during the storage and treatment of animal manure.

The U.S. EPA report titled 'User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool' states that the greater energy content of the feed results in an increased capacity to produce CH_4 in manure. In addition, the report states that the amount of N2O released depends on the system and duration of waste management.

METHODOLOGY
EPA's Emission Inventory Improvement Program developed a series of Excel-based State GHG Inventory Tools, which include an Agriculture Module. The Ag Module calculates CH_4 and N_2O emissions from the agricultural sources. Agricultural sources and activities relevant to Fairfax County were calculated using this tool including Enteric Fermentation, Manure Management, and Ag Soils. The module takes data inputs and applies state-specific data and factors to calculate emissions. The methodologies applied in the tool are generally consistent with EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks.

The US Communities' Protocol does offer similar suggested calculations for enteric fermentation and manure management, where national default factors are applied. While Ag emissions calculated offline can be documented in ClearPath, it does not currently offer a calculator that estimates emissions. At this time, EPA's State Inventory Tool offers the most streamlined calculation process with the most locally relevant default factors for COG's GHG inventory work.

DATA COLLECTION
Metropolitan Washington data inputs into the EPA's State GHG Inventory Tool are pulled at the county-scale from the EPA Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST). CAST is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning.

Data Used:

- Livestock: Livestock population ('000 head) for dairy cows, beef cattle, sheep, goats, swine, horses, pullets, chickens, broilers, and turkeys from the Chesapeake Assessment Scenario Tool.

Notes on Data:

- The CAST model output for Livestock is the Animal Count. It will have to be converted to '000 head to enter into the EPA State Inventory Tool, Ag Module.
- Agricultural data is based on the U.S. Department of Agriculture's AG Census. The AG Census is conducted every 5 years and CAST interpolates data to estimate annual data.

Ag Soils

DESCRIPTION
Ag Soils account for nitrous oxide (N_2O) emissions from animals, crop production, and fertilizer application. The U.S. EPA report titled 'User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool' states that N_2O is naturally produced in soils;

however, animal and crop management practices and fertilizer application increase the amount of N_2O emitted. Higher levels of N_2O are a result of:

- The type of animal waste management systems used;
- Cultivation of certain types of nitrogen-fixing crops;
- Crop residues remaining on agricultural fields; and
- The use of synthetic and organic fertilizer in ag and urban soils.

METHODOLOGY

The U.S. EPA's Emission Inventory Improvement Program developed a series of Excel-based State GHG Inventory Tools, which include an Agriculture Module. The Ag Module calculates methane (CH_4) and N_2O emissions from the agricultural sources. Agricultural sources and activities relevant to Fairfax County were calculated using this tool including Enteric Fermentation, Manure Management, and Ag Soils. The module takes data inputs and applies state-specific data and factors to calculate emissions. The methodologies applied in the tool is generally consistent with EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks.

The US Communities' Protocol does offer similar suggested calculations for enteric fermentation and manure management, where national default factors are applied. While Ag emissions calculated offline can be documented in ClearPath, it does not currently offer a calculator that estimates emissions. At this time, EPA's State Inventory Tool offers the most streamlined calculation process with the most locally relevant default factors for COG's GHG inventory work.

DATA COLLECTION

Metropolitan Washington data inputs into EPA's State GHG Inventory Tool are pulled at the county-scale from the EPA Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST). CAST is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning.

Data Used:

- Livestock: Livestock population ('000 head) for dairy cows, beef cattle, sheep, goats, swine, horses, layers (pullets and chickens), broilers, and turkeys from the Chesapeake Assessment Scenario Tool (CAST).
- Crops: Crop production ('000 bushels) for corn for grain, all wheat, and soybeans from CAST.
- Fertilizer: Fertilizer applied (kg N) for synthetic fertilizers, manure, and biosolids.

Notes on Data:

- Data inputs in county-level Ag Soils calculations includes livestock, crop production, and fertilizer application from synthetic (including urban), manure, and biosolid applications, where appropriate.
- The CAST model output for Livestock is the Animal Count. It will have to be converted to '000 head to enter into the EPA State Inventory Tool, Ag Module.
- Agricultural data is based on the U.S. Department of Agriculture's AG Census. The AG Census is conducted every 5 years and CAST interpolates data to estimate annual data.

SOLID WASTE TREATMENT

Solid Waste

Waste Generation

Landfill Waste Generation

DESCRIPTION
Landfill Waste Generation accounts for the emissions resulting from waste generated by the community in a year and disposed of at a landfill. In other words, it accounts for the resultant methane emissions from the decomposition of biologic solid waste produced by the community that year. Fairfax County's Solid Waste Management Plan 2015 Update states on page 7 of Attachment A that approximately 75% of MSW generated in the county is delivered to the I-66 Transfer Station (primary disposal option is WTE) and 25% is delivered to the Covanta Resource Recovery Center (i.e. WTE) in the county. Therefore, 100% of the County's waste is assumed to go to combustion.

Combustion of Solid Waste Generated by the Community

Combustion of Solid Waste

DESCRIPTION
The Combustion of Solid Waste accounts for the emissions resulting from municipal solid waste (MSW) generated by a community in a year and disposed of at a waste-to-energy (WTE) facility. WTE facilities burn garbage and typically generate steam and/or electricity from the combustion of MSW. According to the U.S. Communities Protocol (USCP), local jurisdictions' MSW, recycling, and composting programs can influence the amount of waste generated, the methods of disposal, and locations.

METHODOLOGY
The Combustion of Solid Waste Generated by the Community emission calculations follow the USCP recommended methodology as outlined in Appendix E, SW.2.2 from Version 1.1 of the Protocol. The calculation used is SW.2.2a. The calculations are based on tons of MSW from Fairfax County going to a WTE.

DATA COLLECTION
The best available municipal MWS data from local and regional sources was used to calculate these emissions. Unlike other activities in this inventory, there is not a regional, state, or federal source of MSW data that comprehensively reports data in the way that is needed for GHG inventory calculations.

Data Used:

- Municipal Solid Waste (MSW): Annual mass in tons of MSW combusted retrieved from local and regional sources.

OTHER

Process and Fugitive Emissions

Substitutes for Ozone Depleting Substances

Hydrofluorocarbon Emissions (HFC)

DESCRIPTION
Hydrofluorocarbons (HFC's) are a type of GHG and are comprised of several organic compounds composed of hydrogen, fluorine, and carbon. HFC's are produced synthetically and are commonly used in air conditioning and refrigerants in place of older halons and chlorofluorocarbons (CFC's), which were attributed to the depletion of Earth's Ozone layer. Following the implementation of the Montreal Protocol, HFC's gradually replaced CFC's because of their minimal impact on the Ozone layer, having an Ozone depletion potential of zero. However, HFC's are potent greenhouse gases (HFC's are 3,830 times more potent than CO_2) with high global warming potentials.

METHODOLOGY
HFC emissions in this inventory represent GHG emissions from substitutions for Ozone depleting substances. Total U.S emissions from substitutes for Ozone depleting substances are scaled locally by population to estimate jurisdictional and regional values. Substitutions for Ozone depleting substances primarily result in HFC emissions; however, small amounts of perfluorocarbon (PFC) emissions also result from this source.

DATA INPUTS
Local data on substitutes for Ozone depleting substances is not available. It would take extensive research and local surveys to develop this data. Although emissions from these substances continues to expand, it only accounts for a small portion of emissions. The U.S. Environmental Protection Agency's annual inventory reports on GHG emissions calculates nationwide emissions for substitutes for Ozone depleting substances.

Data Needs:

- Population: Population data for Fairfax County, as well as U.S. totals, are collected from the American Community Survey.
- U.S. Emission of Ozone Depleting Substances: National data for HFC emissions is recorded in Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2e$) from the U.S. EPA, Inventory of U.S. GHG Emissions and Sinks – 1990-2015.

Fugitive Emissions from Natural Gas Distribution

Natural Gas Fugitive Emissions

DESCRIPTION
Natural Gas Fugitive Emissions accounts for emissions resulting from local natural gas system losses within Fairfax County.

METHODOLOGY

The Fugitive Emissions from Natural Gas emission calculations uses the ClearPath calculator developed after the latest version of the U.S. Communities Protocol was published (Version 1.1). ICLEI, author of the Protocol, intends to outline the method in the next edition of the Protocol under development. The fugitive emissions are calculated based on a leakage rate for total annual natural gas consumption. The ClearPath calculator uses a leakage rate of 0.3%.

DATA COLLECTION

Data from the Metropolitan Washington Annual Utility survey needs to first be collected and analyzed for the inventory year prior to completing these steps. See the residential and natural gas under the Built Environment section of this report.

Data Needs:

- Natural Gas Consumption: Total Annual Therms for Fairfax County from the analyzed results of the Metropolitan Washington Annual Utility Survey.

EMISSIONS PROJECTIONS

Business-As-Usual (BAU) Projections

Residential Energy

Electricity Consumption

BAU Residential Electricity projections were built out based on 2018's annual electricity consumption. Residential existing buildings electricity consumption kept 2018's annual consumption constant through to 2050. New Construction electricity consumption estimates the way that anticipated growth will be distributed in Fairfax County based on household growth and household energy intensity statistics. COG's Cooperative Forecast Round 9.1 was used to project household growth out to 2045 in five year increments. As there is currently no official projection for 2050, the trend from 2019 to 2045 was used to project the final five years. Household energy intensity was projected out using data from the U.S. Energy Information Administration's (EIA) 2015 Residential Energy Consumption Survey. Average site energy consumption by housing unit type was used to establish a composite household energy intensity and reflect an analysis of energy code improvements for new construction from ICF, which was used in conjunction with household growth to calculate an annual energy growth estimate. Total residential electricity consumption was calculated by adding existing and new construction electricity consumption projections. An eGRID emissions factor was then applied to these consumption numbers to calculate total residential electricity GHG emissions projections from 2019 to 2050. The eGRID emissions factor was taken from the EPA's 2018 eGRID factors for the SRVC Grid Sub-Region.

Gas Consumption

BAU Residential Gas Consumption projections were built out based on 2018's annual natural gas consumption. Residential existing buildings natural gas consumption kept 2018's annual consumption constant through to 2050. New Construction natural gas use estimates were calculated in a similar manner to new construction electricity use. These estimates anticipate how growth will be distributed in Fairfax County based on household growth and household energy intensity statistics. COG's Cooperative Forecast Round 9.1 was used to project household growth out to 2045 in five year increments. As there is currently no official projection for 2050, the trend from 2019 to 2045 was used to project the final five years. Household energy intensity was projected out using data from the U.S. Energy Information Administration's (EIA) 2015 Residential Energy Consumption Survey. Average site natural gas consumption by housing unit type was used to establish a composite household energy intensity and reflect an analysis of energy code improvements for new construction from ICF, which was used in conjunction with household growth to calculate an annual natural gas growth estimate. Total residential natural gas consumption was calculated by adding existing and new construction natural gas consumption projections. An emissions factor was then applied to these consumption numbers to calculate total residential natural gas GHG emissions projections from 2019 to 2050. The emissions factor was taken from the Local Government Operations Protocol Tables G1 & G3 from the IPCC's 4th Assessment Report.

Fuel Oil & LPG

The emissions rate from these sources was held constant from inventory year 2018.

Commercial Energy

Electricity Consumption

BAU Commercial Electricity projections were built out based on 2018's annual electricity consumption. Commercial existing buildings electricity consumption kept 2018's annual consumption constant through to 2050. New Construction estimates the way that anticipated growth will be distributed in Fairfax County based on commercial sector growth and commercial building energy intensity statistics. COG's Cooperative Forecast Round 9.1 was used to project commercial sector growth out to 2045 in five year increments through the use of employment projections and 2018 Commercial Construction Indicators. The commercial construction indicators projected square footage of new commercial building space per 1,000 job additions to project new commercial space by year. As there is currently no official projection for 2050 employment, the trend from 2019 to 2045 was used to project the final five years. Commercial building energy intensity was projected out using data from the U.S. Energy Information Administration's (EIA) 2012 Commercial Buildings Energy Consumption Survey. Average site energy consumption by commercial building type was used to establish a composite building energy intensity, which was used in conjunction with commercial space growth to calculate an annual energy growth estimate. Total commercial electricity consumption was calculated by adding existing and new construction electricity consumption projections. An eGRID emissions factor was then applied to these consumption numbers to calculate total commercial electricity GHG emissions projections from 2019 to 2050. The eGRID emissions factor was taken from the EPA's 2018 eGRID factors for the SRVC Grid Sub-Region.

Gas Consumption

BAU Commercial Gas Consumption projections were built out based on 2018's annual natural gas consumption. Commercial existing buildings natural gas consumption kept 2018's annual consumption constant through to 2050. New Construction natural gas use estimates were calculated in a similar manner to new construction electricity use. These estimates anticipate how growth will be distributed in Fairfax County based on commercial sector growth and commercial building energy intensity statistics. COG's Cooperative Forecast Round 9.1 was used to project commercial sector growth out to 2045 in five year increments through the use of employment projections and 2018 Commercial Construction Indicators. The commercial construction indicators projected square footage of new commercial building space per 1,000 job additions to project new commercial space by year. As there is currently no official projection for 2050 employment, the trend from 2019 to 2045 was used to project the final five years. Commercial building energy intensity was projected out using data from the U.S. Energy Information Administration's (EIA) 2012 Commercial Buildings Energy Consumption Survey. Average site natural gas consumption by commercial building type was used to establish a composite building energy intensity, which was used in conjunction with commercial space growth to calculate an annual natural gas consumption estimate. Total commercial natural gas consumption was calculated by adding existing and new construction consumption projections. An emissions factor was then applied to these consumption numbers to calculate total commercial natural gas GHG emissions projections from 2019 to 2050. The emissions factor was taken from the Local Government Operations Protocol Tables G1 & G3 from the IPCC's 4th Assessment Report.

Fuel Oil & LPG

The emissions rate from these sources was held constant from inventory year 2018.

On Road Mobile Emissions

The BAU forecast for On Road transportation utilizes Fairfax County Summary data for Vehicle Miles Travelled (VMT) and MTCO2e as estimated by COG's MOVES model to 2045. These are used to derive simple MTCO2e/mi rates that vary across the region as a result of the differences in road network and other factors between counties. As there is currently no official projection for 2050 VMT or GHG emissions from on road transportation, the trends from COG's MOVES model were used to project the final five years.

Off Road Mobile Emissions

Under the assumption that MOVES outputs are primarily construction and other equipment, the emissions rate from off road mobile sources was held constant from inventory year 2018.

Commuter Rail

The emissions rate from commuter rail was held constant from inventory year 2018.

Natural Gas Fugitive Emissions

Natural gas fugitive emissions are projected out to 2050 using the annual natural gas consumption in therms taken from Residential and Commercial Gas estimates, and an emissions rate taken from the 2018 inventory (this emissions rate is the same as the rate from the 2015 inventory).

HFCs

Fugitive HFC emissions are based on derived emissions per capita, multiplied by expected population increases. Population estimates from 2015 to 2045 were taken from COG's Cooperative Forecast Round 9.1. This five year incremental trend in population growth was used to estimate 2050's population. Using a per capita HFC emissions factor taken from the 2018 inventory, HFC emissions could be forecasted out to 2050 in conjunction with population estimates.

Wastewater Treatment

Wastewater emissions for both septic and sewer treatment were based on derived emissions per capita and the percentage of the population in Fairfax County using the treatment method, multiplied by expected population increases. Population estimates from the COG Cooperative Forecast Round 9.1 were used for these projections, along with the percentage of population in Fairfax County using either treatment method based on the 2018 inventory.

Waste

Solid Waste Combustion Emissions projections were based on derived waste generation per capita, multiplied by expected population growth, similar to wastewater treatment projections. These projections assume no change in disposal practices. Fairfax County's Solid Waste Management Plan 2015 Update states on page 7 of Attachment A that approximately 75% of MSW generated in the county is delivered to

the I-66 Transfer Station (primary disposal option is WTE) and 25% is delivered to the Covanta Resource Recovery Center (i.e. WTE) in the county. 100% of the County's waste is assumed to be combustion. Thus, no emissions from solid waste sent to landfill are projected out to 2050.

Agriculture

Changes in Agricultural emissions are based on recent trends in acres of land in production as a proxy. A decreasing annual rate of change was used based on changes in acres of land in farms from 2007 to 2012 taken from COG's What Our Region Grows Report (2019).

APPENDIX A: 2018 METHODOLOGY SUMMARY TABLE

Emissions Type	Emissions Activity or Source	GHG Types (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6)	Methodology (From US Communities Protocol, v 1.1)	Data Quality Confidence Levels (High, Medium, Low)
BUILT ENVIRONMENT				
Residential Energy	Emissions from Grid Electricity *	CO_2, CH_4, N_2O	Appendix C, BE.2.1	High
	Emissions from Stationary Fuel (Natural Gas) *		Appendix C, BE.1.1	High
	Emissions from Stationary Fuel (Fuel Oil, LPG) *		Appendix C, BE.1.2	Medium
Commercial and Industrial Energy	Emissions from Grid Electricity *	CO_2, CH_4, N_2O	Appendix C, BE.2.1	High
	Emissions from Stationary Fuel (Natural Gas) *		Appendix C, BE.1.1	High
	Emissions from Stationary Fuel (Fuel Oil, LPG) *		Appendix C, BE.1.3	Medium
	Industrial Point Source Emissions from Stationary Fuel Combustion	Any GHG	IE in commercial and industrial stational fuel and solid waste	N/A
	Consumption of District Energy	CO_2, CH_4, N_2O	IE in commercial and industrial grid electricity and stational fuel	N/A
TRANSPORTATION AND MOBILE EMISSIONS				
Transportation and Mobile Emissions	On Road Transportation *	CO_2, CH_4, N_2O	Appendix D, TR.1.A	High
	Emissions from Public Transit *		IE in On Road	N/A
	Rail Transportation *		Appendix D, TR.4	Medium
	Emissions from Off Road Vehicles *		Appendix D, TR.8	High
	Water Transportation *		IE in Non-Road	N/A
WASTEWATER TREATMENT				
Water and Wastewater	Emissions from Wastewater Treatment Energy Use *	CO_2, CH_4, and N_2O from electricity and fuels	IE in commercial and industrial energy	N/A
	Emissions from the Supply of Potable Water *	CO_2, CH_4, and N_2O from electricity and fuels	IE in commercial and industrial energy	N/A
	Fugitive Emissions from Septic Systems*	Fugitive CH_4	Appendix F, WW.11	High
	Nitrification/Denitrification Process N2O Emissions from Wastewater Treatment *	Process N_2O	Appendix F, WW.7	High
	Process N2O from Effluent Discharge to Rivers and Estuaries *	Fugitive N_2O	Appendix F, WW.12	High
AGRICULTURE				
Agriculture	Emissions from Agricultural Activities	CH_4, N_2O	Alternate Method - EPA State Inventory Tool, AG Module	High
	Emissions from Stationary Fuel Combustion	CO_2, CH_4, N_2O	IE in commercial and industrial grid electricity and stational fuel	N/A
	Emissions from Grid Electricity			

Emissions Type	Emissions Activity or Source	GHG Types (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6)	Methodology (From US Communities Protocol, v 1.1)	Data Quality Confidence Levels (High, Medium, Low)
SOLID WASTE TREATMENT				
Solid Waste	Waste Generation (Landfill) *	Fugitive CH_4	Appendix E, SW.4	Medium
	Process Emissions Associated with Landfilling	CO_2e	NE	N/A
	Combustion of Solid Waste Generated by the Community *	Fossil CO_2, N_2O, CH_4 (biologic CO_2 optional)	Appendix E, SW.2.2	Medium
	Biologic Treatment of Solid Waste (Composting)	CO_2, CH_4, N_2O	NE	N/A
OTHER				
Process and Fugitive Emissions	Other Process and Fugitive	HFCs, PFCs, Refridgerant Blends	Alternate Method - Downscale from national inventory	High
	Fugitive Emissions from Oil Systems, Mining, Processing, Storage, and Transportation of Coal	CO_2, CH_4, N_2O	NE	N/A
	Fugitive Emissions from Natural Gas Distribution	CO_2, CH_4	ClearPath calculator	High
Upstream Impacts of Activities	Upstream Impacts of Electricity Used by the Community	CO_2, CH_4, N_2O	NE	N/A
	Upstream Impacts of Fuels Used in Stationary Combustion by the Community			
	Emissions from Electric Power Transmission and Distribution Losses			
Consumption Based	Consumption Based Emissions, Previously Calculated	Any GHG	NE	N/A

Column Header	Description
Emissions Type	This column lists the main tabs in the online ClearPath tool's GHG inventory entry pages in the same order listed in ClearPath.
Emissions Activity/Source	This column lists the ClearPath calculators that are used to calculate or record emissions from activities/sources. * Indicates that reporting for this activity or source is required by the U.S. Community Protocol or Global Protocol for Communitiy-Scale GHG Inventories (BASIC). Those without a * are not requirements of the protocols.
GHG Types	Summarizes the leading GHG emission types that result from each activity or source, including carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
Methodology	The methodologies and calculations generally follow ICLEI's US Community Protocol for Accounting and Reporting GHG Emissions Version 1.1. Modified approaches to the ICLEI methodology are used based on data availability. In addition, notations are made in accordance with the Notation Keys legend below.

Notation Keys	Description
IE = Included Elsewhere	Emissions for this activity are estimated and presented in another category of the inventory. The category where these emissions are included should be noted in explanation.
NE = Not Estimated	Emissions occur but have not been estimated or reported (e.g., data unavailable, effort required not justifiable).
NA = Not Applicable	The activity occurs but does not cause emissions; explanation should be provided.
NO = Not Occurring	The source or activity does not occur or exist within the community.

Note: These notations were developed by the Global Communities Protocol and are also used by the U.S. Communities Protocol. See Version 1.1, 2012, Appendix B.