Community Greenhouse Gas Inventory for Fairfax County, Virginia, 2006–2010

1 INTRODUCTION

1.1 Background

This report provides a multi-year greenhouse gas (GHG) emissions inventory for Fairfax County, Virginia, for calendar years 2006 through 2010. Situated in the western portion of the Washington, D.C., metropolitan region (Figure 1), Fairfax County is approximately 400 square miles in area, with a 2010 population of 1.1 million people.

Figure 1: Fairfax County, Virginia

Key GHG Inventory Concepts

Naturally occurring GHGs include water vapor, carbon dioxide, methane, nitrous oxide and ozone. Each gas absorbs and emits infrared radiation, generating warmth in the process. Certain human activities, notably fossil fuel combustion, augment atmospheric GHG concentrations, thereby magnifying the warming effect. Industrial processes also create man-made GHGs, notably fluorinated gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

A typical national GHG inventory accounts for six chemicals. In 2006, three GHGs – carbon dioxide, methane and nitrous oxide – accounted for more than 98% of the United States' CO_2e (3).[2] The three synthetic fluorinated gases accounted for the remainder. At the community scale, these GHG emissions span many economic sectors, including residences, business and commerce, industry, government, transportation, waste management and agriculture. (6).

The territory over which a local government has jurisdictional authority provides the boundary for its community GHG inventory. Each GHG source in the community may produce *direct* emissions inside this boundary as well as *indirect* emissions from activities within the boundary that result in emissions outside the boundary. For inventory reporting purposes, a community's direct and indirect emissions are classified into three scopes, reflecting degrees of expected community control:

Scope 1. Direct emissions from sources within the community boundary.

Scope 2. Energy-related indirect emissions from grid-supplied electricity, heating and/or cooling outside the boundary due to consumption within the boundary.

Scope 3. Other indirect emissions outside the boundary due to activities within the boundary, such as from the trans-boundary exchange of goods, services or waste.

Emerging global standards for community GHG inventories advise including Scope 1 and Scope 2 emissions from stationary sources, mobile sources and industrial processes and product use, and Scope 3 emissions from the waste sector. These basic components "enable local government leaders to make policy-relevant conclusions […] by identifying and prioritizing the accounting of key community-scale GHG emissions drivers." The protocol permits inventories to exclude "one or more emissions sources,

[2] Carbon dioxide equivalent, or CO_2e, is the international standard used for expressing GHG emissions for various gases.

for one or more emissions gases which, when summed, represent less than 5% of total GHG emissions." These are *de minimis* sources of emissions, which are often relatively small, unimportant and difficult to accurately measure and quantify.

1.2 Methodology

At the time this inventory was developed, there was no established protocol for developing a communitywide GHG emissions inventory. Consequently, the development of this inventory relied upon protocols established by the Climate Registry and its partners, including General Reporting Protocol (GRP) and Local Government Operations Protocol (LGOP). In addition, this inventory reflects general guidance from the International Local Government GHG Emissions Analysis Protocol and a communitywide emissions inventory conducted by Arlington County, Virginia, which is adjacent to Fairfax County.

Focus

Energy generation and consumption account for the vast majority of GHG emissions in the United States and Virginia and almost all GHG emissions in Fairfax County. Energy accounted for 87% of total U.S. GHG emissions in 2006 and 90% of Virginia's GHG emissions in 2005. Energy, agriculture, industry and waste together produced over 99% of their inventoried emissions. The percentage of GHG emissions attributable to energy in Fairfax County is even higher, as the county has virtually no agriculture or industrial activity and uses municipal waste for waste-to-energy power generation.

Fairfax County's energy-related GHG emissions reasonably approximate its total GHG emissions. As a result, the county's GHG inventory focuses on Scope 1 and Scope 2 emissions from energy use by stationary and mobile sources within the county's jurisdictional boundary. These emissions are from the transportation, residential, commercial, local government and industrial sectors. These five sectors are defined in descending order from most to least significant as follows:

- *Transportation* (37% of total): On-road vehicles (passenger vehicles, motorcycles, light duty trucks and sport utility vehicles (SUVs), buses and heavy duty trucks), Metrorail rapid transit, Virginia Railway Express (VRE) commuter rail, off-road vehicles, engines and equipment. This incorporates the mobile units from all sectors. On-road vehicles registered within the county (local vehicles) are distinguished from those passing through the county (transient vehicles). Watercraft is scarce and aviation, although present within the region, is largely absent within the jurisdictional boundary of the county.

- *Residential* (29% of total): Private households, including apartment houses, which consume energy primarily for space heating, water heating, air conditioning, lighting, refrigeration, cooking and clothes drying.

- *Commercial* (29% of total): Nonmanufacturing business establishments, including hotels, motels, restaurants, wholesale businesses, retail stores and health, social and educational institutions. Where the use is both residential and commercial, sector is based on principal use.

- *Local government* (3% of total): Various facilities operated by county departments and agencies, including schools, libraries, fire stations and waste management facilities, as well as streetlights.

- *Industrial* (2% of total): Manufacturing, construction, mining, agriculture, fishing and forestry.

Eight categories of greenhouse emissions were excluded from this inventory. These categories and the reasons for their exclusion are:

1. Emissions from sources outside the county's jurisdictional boundary:

   a. *Federal and state facilities and properties*, including military bases, airports and buildings either owned or leased by the federal or state governments.

   b. *Utility transmission losses*, which are considered the responsibility of the utility.

2. Emissions that are *de minimis* in Fairfax County:

   a. *Agriculture, forestry and related industry*, which are virtually nonexistent in Fairfax County.

   b. *Waste-related emissions*, which are minimal due to Fairfax County's recycling and waste-to-energy facilities. Emissions from the county's waste-to-energy (WTE) plant, which can burn up to 3,000 tons of municipal solid waste per day and generate up to 80 megawatts of electricity per year, as the literature indicates that the facility is neutral to negative in net CO2e emissions (http://pubs.acs.org/doi/pdf/10.1021/es802395e).

3. Emissions that are currently non-quantifiable due to a lack of available data regarding use or consumption in the commercial, residential, and industrial sectors:

a. *Fugitive emissions* from refrigerant use that are released during equipment installation, use, servicing, or disposal.[1]

b. *Fluorinated gases*, which account for less than 2% of emissions in both Commonwealth of Virginia 2005 and United States' 2006 GHG inventories (http://www.sealevelrisevirginia.net/docs/homepage/GHG_Inventory_final_draft.pdf & http://www.epa.gov/climatechange/ghgemissions/gases.html).

c. *Stationary liquid fuels*, except where reported as part of Fairfax County's local government operations.

4. Emissions from water distribution systems, except as related to the operations of the county's Noman M. Cole Jr. Pollution Control Plant and reported as part of Fairfax County's local government operations.[2]

Reducing water use is a good strategy for reducing greenhouse gas emissions. These Scope 3 activities, however, are not included in inventories of Scope 1 and 2 emissions. The exception to this is for agencies involved in the production and distribution of water or the pumping or treatment of wastewater. For these agencies the resulting greenhouse gas emissions are represented in their overall Scope 1 and Scope 2 inventory of energy consumption.

For more information on Scope 3 emission sources see The Climate Registry: "Local Government Operations Protocol for the quantification and reporting of greenhouse gas emissions inventories" version 1.1 http://www.theclimateregistry.org/downloads/2010/05/2010-05-06-LGO-1.1.pdf

[1] The county estimated fugitive emissions at 0.004% of total emissions from local government operations, based on a simplified material balance method.

[2] Energy use and corresponding emissions are included for those County agencies involved in the production and distribution of potable water or the pumping or treatment of wastewater. However, for most Fairfax County Government agencies, residents and businesses, the energy use and consequential greenhouse gas emissions from the use of water distribution is not within the direct financial or operational control of the agency, individual or business consuming the water. These greenhouse gas emissions therefore are considered a Scope 3 emissions source that is excluded from this inventory.

Data Collection and Processing

Area utilities, federal and commonwealth agencies, the Metropolitan Washington Council of Governments and various Fairfax County government departments each contributed input data for this countywide GHG inventory. Total GHG emissions were then calculated from the sum of GHG emissions from each measured source, sector and energy usage type.

Because the county's inventory is focused on energy-related GHG emissions, GHG emissions from stationary sources reflect the use of electricity or natural gas in the commercial, residential, local government and industrial sectors. Local government agencies and utilities provided direct measurements of stationary energy use for electricity, natural gas and fuels. GHG emissions from mobile sources in the transportation sector generally reflect the use of gasoline or diesel fuel. For on-road vehicles (excluding the local government fleet), this fuel use was estimated as a function of vehicle miles traveled divided by fleet mileage (MPG). Comparable indirect methods were used for local trains, off-road vehicles, engines and machines.

GHG emissions are measured in units of metric tons carbon dioxide equivalent ($MTCO_2e$) per year. CO_2e is the international standard for expressing GHG emissions for various gases (4). GHGs are converted into CO_2e by multiplying their mass times a chemical-specific global warming potential (GWP) (3,4).

On an annual basis, each source's contribution to total emissions was calculated as:

$$\text{Emissions (in } MTCO_2e) = \text{Energy x Conversion Factor}$$

where energy is the total amount of energy of one type (in kilowatt hours, therms or gallons) used in the county (Scope 1) or as a result of activities within the county (Scope 2) in a given year. Conversion factors for this inventory are presented as Table B-7, Energy-to-CO_2e conversion factors used in this inventory, in Appendix B.

A conversion factor is derived from a type of energy's emission factor and the GWP for each GHG. To do so, emissions factors – defined as the amount of carbon dioxide, methane and nitrous oxide emitted per unit of energy use in that year – are multiplied by the GWP for each chemical: 1 for carbon dioxide, 21 for methane, and 310 for nitrous oxide. Summing the result creates the conversion factor for $MTCO_2e$ per unit of that energy for the year. That is:

Conversion Factor	= sum of (emissions factor x GWP) for all GHGs	
	= carbon dioxide per unit of energy	x 1
	+ methane per unit of energy	x 21
	+ nitrous oxide per unit of energy	x 310,

where	GWP for carbon dioxide	=	1
	GWP for methane	=	21
	GWP for nitrous oxide	=	310.

While GWP values remain constant, emissions factors may vary from year to year due to the blend of fuels used to generate electricity for the regional grid, such as the ratio of nuclear fuel to fossil fuel. The resulting annual conversion factor may vary by 2% per kWh, as it did in the county's Virginia/Carolina sub-region between 2006 and 2010.

Total GHG emissions for a particular year were produced by summing emissions per the calendar year across all energy types, sectors and sources.

1.3 Overview of Results

For the baseline year 2006, Fairfax County's energy-related GHG emissions were 11,838,076 $MTCO_2e$ or 11.41 $MTCO_2e$ per county resident. Figure 2 shows that transportation accounted for 37% of total county GHG emissions. Stationary sources accounted for the remaining 63% of total GHG emissions. Residential and commercial sectors each accounted for 29%, local government 3% and industry 2% of emissions.

Figure 2: 2006 Fairfax County GHG emissions, by sector

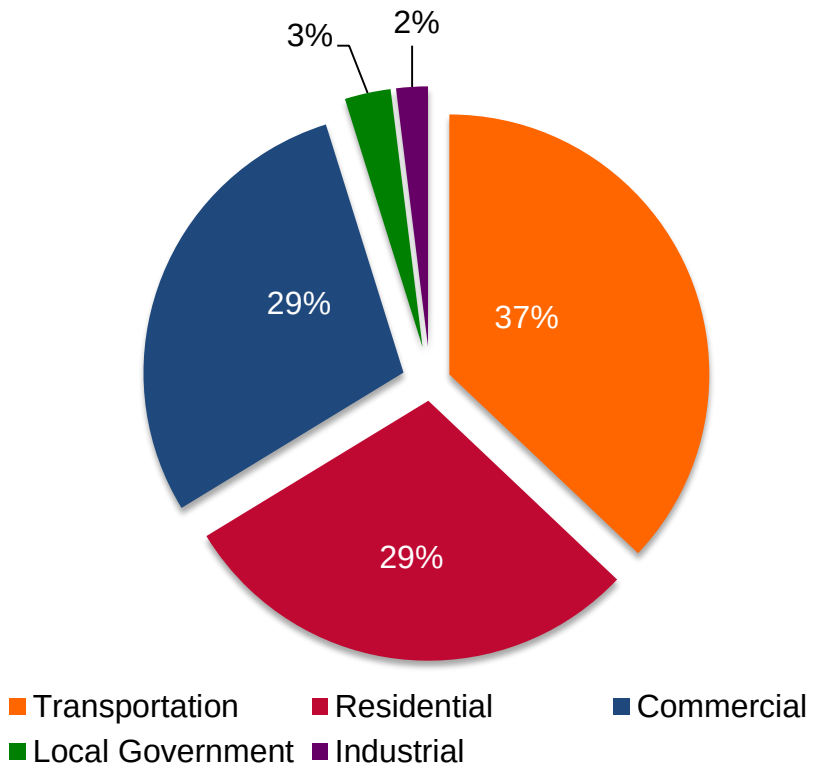
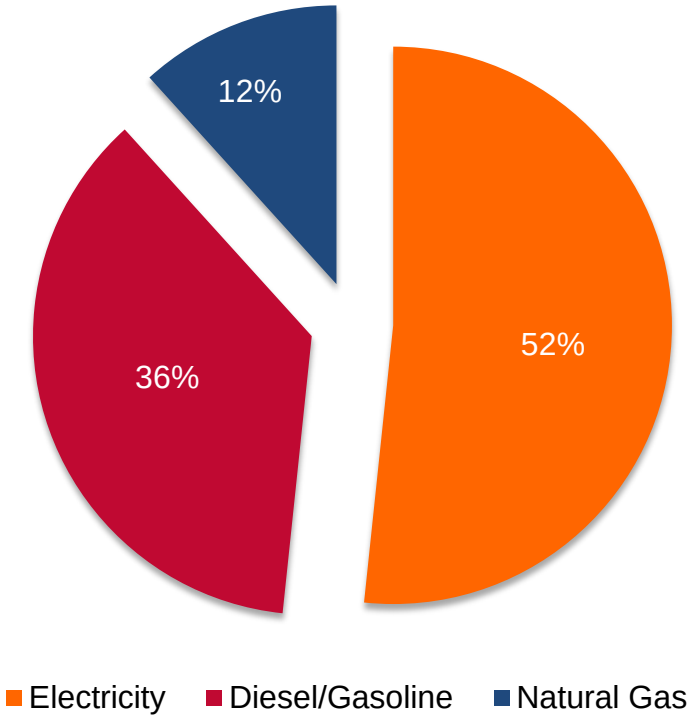


Figure 3 presents GHG emissions by energy type. Electricity and natural gas consumption by stationary sources produced 64% of all recorded GHG, with the vast majority – 52% – due to electricity consumption. Combustion of mobile fuels – diesel and gasoline – produced 36% of GHGs.

Figure 3: 2006 Fairfax County GHG emissions, by energy type



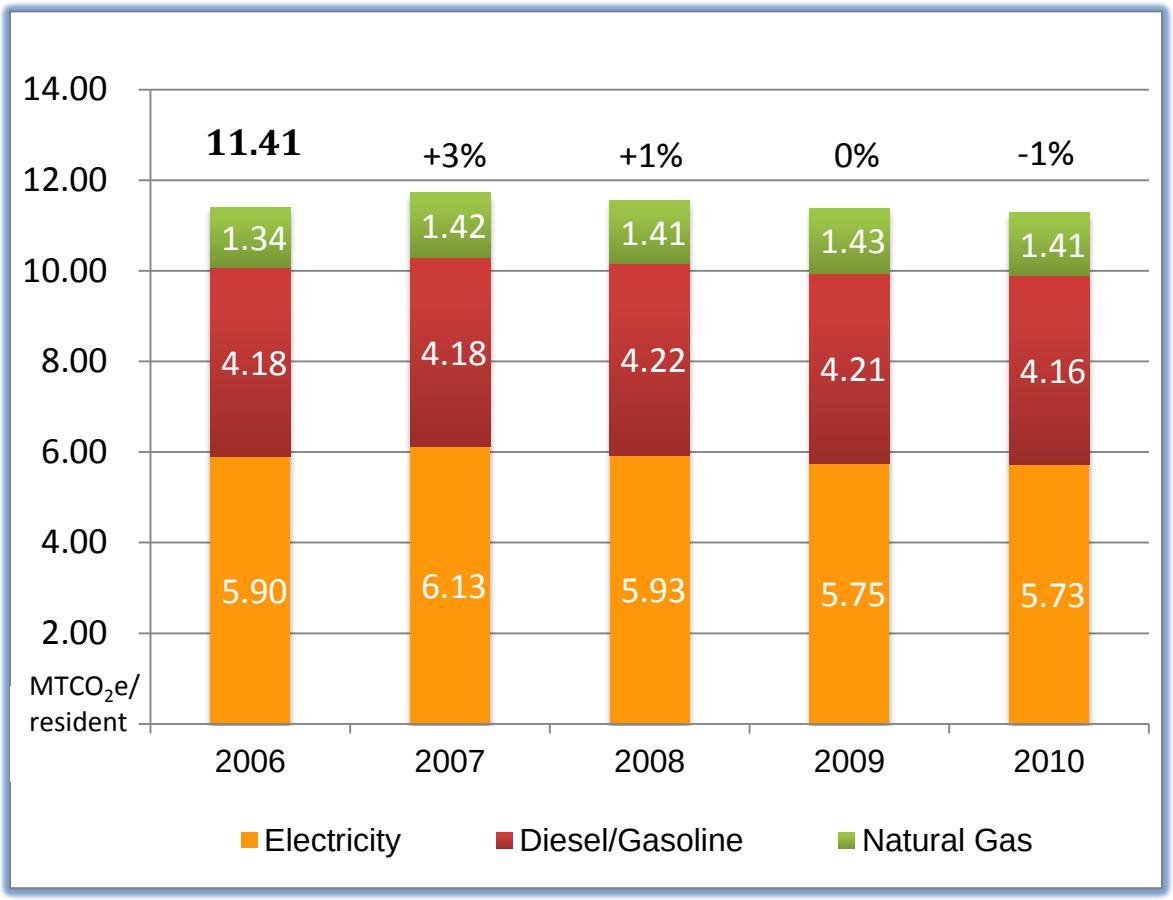
Communitywide, Fairfax County's total GHG emissions rose 3% from 2006 to 2010, per Table 1, below. Scope 1 – combustion within county boundaries – increased 2% in 2007, then an additional 1% in each following year. Thus, Scope 1 GHGs were 5% greater in 2010 than in 2006. Scope 2 – electricity consumption – increased 3% from 2006 to 2007, but then decreased, ending 2010 only 1% above 2006 levels. Over the five-year period, GHGs from stationary sources climbed 3%, less than the county's 4% population growth. Mobile emissions rose 4%, in line with that growth.

Table 1: Trends in GHG emissions across scopes and sources, 2006-2010

Emissions (Million MTCO2e)	2006	2007	2008	2009	2010
All sources	11.838	12.211	12.097	11.978	12.217
-- Change vs. 2006	--	+3%	+2%	+1%	+3%
Scope 1 (combustion)	5.721	5.831	5.892	5.931	6.021
-- Change vs. 2006	--	+2%	+3%	+4%	+5%
Scope 2 (electricity)	6.117	6.380	6.205	6.047	6.197
-- Change vs. 2006	--	+4%	+1%	-1%	+1%
Stationary Sources	7.450	7.803	7.630	7.504	7.663
-- Change vs. 2006	--	+5%	+2%	+1%	+3%
Mobile Sources	4.388	4.408	4.467	4.474	4.554
-- Change vs. 2006	--	+0%	+2%	+2%	+4%
Population vs. 2006	--	+0%	+1%	+1%	+4%

For the five-year period, GHG emissions per resident rose in 2007 relative to 2006, then declined below 2006 levels by 2010. Figure 4 displays how this decline was primarily due to a fall in per capita electricity and, to a limited extent, mobile fuel combustion. By contrast, natural gas emissions per resident increased from 2006 to 2010.

Figure 4: Fairfax County annual emissions per resident, by energy type, with percent change relative to 2006



Sections 2 and 3 elaborate upon the approach and results for stationary sources and mobile sources, respectively. Section 4 provides a discussion of these findings.