COMMUNITY GREENHOUSE GAS INVENTORY FOR FAIRFAX COUNTY, VIRGINIA

Report of Findings: 2006-2010

April 2013

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EXECUTIVE SUMMARY

This report presents a community greenhouse gas emissions (GHG) inventory for Fairfax County, Virginia. These emissions come from both stationary and mobile sources, as a result of commercial, residential, industrial, local government and transportation activities within the jurisdictional boundaries of the county. The inventory establishes 2006 as its baseline year. It then tracks annual emissions for the five-year period from 2006 through 2010.

During the study, there were no nationally recognized guidelines for undertaking a community GHG emissions inventory. Consequently, the county developed its own methodology based on protocols established by the Climate Registry, similar to the approach undertaken by adjacent Arlington County, Virginia.

The Fairfax County GHG inventory includes both direct (Scope 1) emissions generated within the county and energy-related indirect (Scope 2) emissions. Scope 2 emissions result from purchased electricity that is consumed inside the county, regardless of where it was generated.

Greenhouse gases considered include carbon dioxide, methane and nitrous oxide. These three chemicals, all related to energy production and consumption, together made up more than 98% of United States' GHG emissions in 2006 (3). Other emissions were deemed either outside the county's political jurisdiction, insignificant and/or infeasible to accurately measure across sectors at the county scale. Data to calculate emissions were provided by federal and commonwealth agencies, the Metropolitan Washington Council of Governments (MWCOG), public utilities providing service in Fairfax County and Fairfax County Government.

The county's total GHG inventory is composed of the sum of energy-related GHG emissions from stationary and mobile sources. Stationary sources encompass buildings or other fixed, energy-consuming property not attributable to federal or state governments. Stationary energy use includes electricity, natural gas and a tiny amount of fuel oil. Mobile emissions include those associated with on-road traffic originating in and passing through the county, as well as light rail, off-road vehicles and mobile machinery (e.g., lawnmowers). Mobile sources predominantly use gasoline or diesel fuel.

Figure ES-1 and Figure ES-2 present the distribution of 2006 emissions across various stationary and mobile sources, respectively. Stationary sources accounted for 63% of the county's total GHG emissions, primarily from electricity use. As shown in Figure ES-1, residential and commercial sectors each comprised about 46% of stationary

emissions. Local government (including public schools) and industry comprised about 5% and 3%, respectively.

Mobile sources accounted for 37% of total GHG emissions in the county. About 89% of mobile emissions came from on-road vehicles. As shown in Figure ES-2, of this 89%, 46% was attributable to vehicles passing through the county (transient vehicles) and 43% to vehicles registered in the county (local vehicles). Off-road vehicles and machinery comprised 10% of mobile emissions. Together, Metrorail and Virginia Railway Express (VRE) trains accounted for approximately 1% of mobile emissions.

Figure ES-1: Distribution of 2006 GHG emissions from stationary units

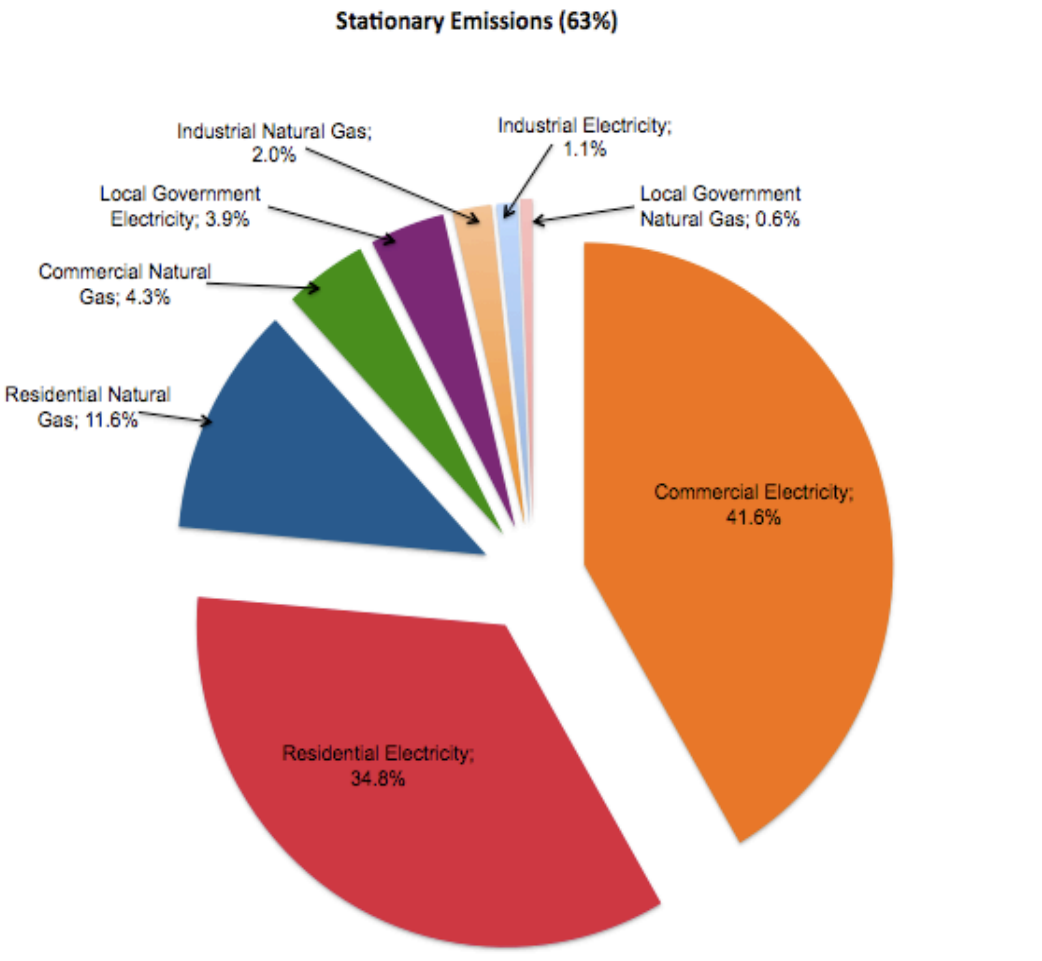

Figure ES-2: Distribution of 2006 GHG emissions from mobile units

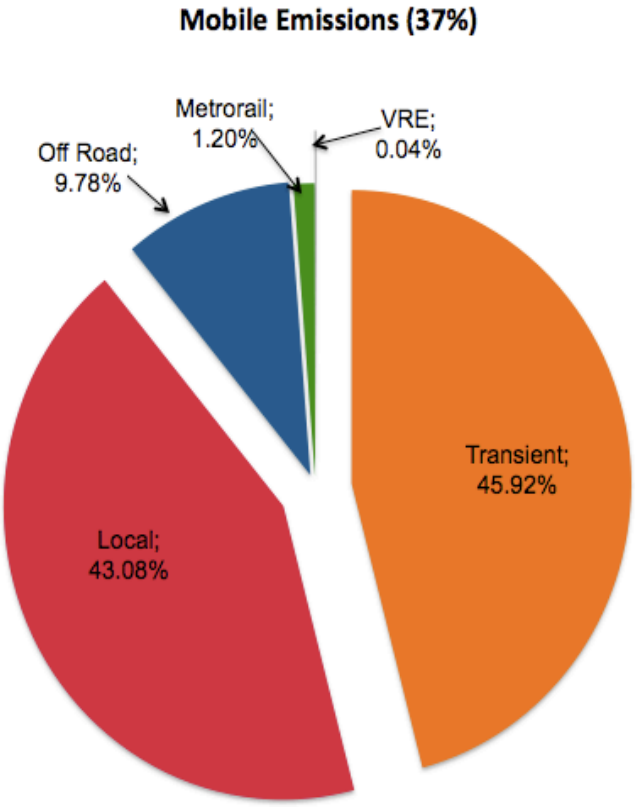

Table ES-1 displays 2006 emissions by sector and source. Total energy-related GHG emissions in 2006 were 11.83 million metric tons of carbon dioxide equivalent (Million MTCO2e), or about 11.41 $MTCO_2e$ per county resident.

As shown in Table ES-1, the majority of stationary emissions were from the residential and commercial sectors, each of which contributed 29% of total emissions. The majority of mobile emissions were from on-road vehicles. Passenger vehicles and motorcycles contributed 24% of total emissions.

Table ES-1: Fairfax County 2006 GHG emissions by source and sector[1]

Emissions Sector and Source	Million MTCO2e* in 2006	2006 Emissions (%)
Stationary Sources		
Residential	3.459	29%
Commercial	3.420	29%
Local government	0.339	3%
Industrial	0.233	2%
Subtotal	**7.450**	**63%**
Mobile Sources		
Passenger vehicles	2.822	24%
Heavy trucks	0.596	5%
Light trucks	0.486	4%
Other	0.484	4%
Subtotal	**4.388**	***37%***
TOTAL	**11.838**	**100%**

From 2006 to 2010, yearly GHG emissions rose by 3%, as shown in Table ES-2. Since population grew more than 4% over this period, emissions per resident declined by 1%. This decline resulted from notable drops in commercial (-5%) and industrial (-19%) emissions, countered by slight increases in residential (+3%) and local government (+1%) emissions per resident. By contrast, mobile GHG emissions per resident were constant.

Table ES-2: Year-to-year change in GHG emissions from 2006 to 2010

	2006	2007	2008	2009	2010
Million MTCO2e	11.838	12.211	12.097	11.978	12.217
-- Change vs. 2006	--	+3%	+2%	+1%	+3%
$MTCO_2e$ per resident	11.41	11.72	11.57	11.39	11.30
-- Change vs. 2006	--	+3%	+1%	-0%	-1%

This report includes three appendices. Appendix A provides a list of abbreviations. Appendix B describes methods and calculations. Appendix C details energy use and GHG emissions results by sector and year.

[1] Due to rounding, figures may not sum to subtotals or totals.

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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:

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

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

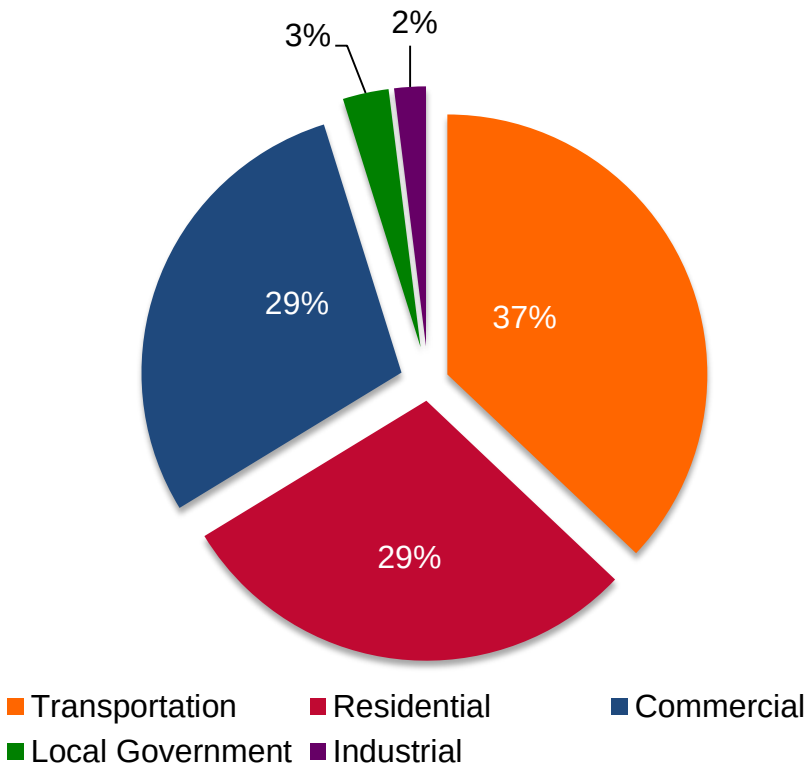
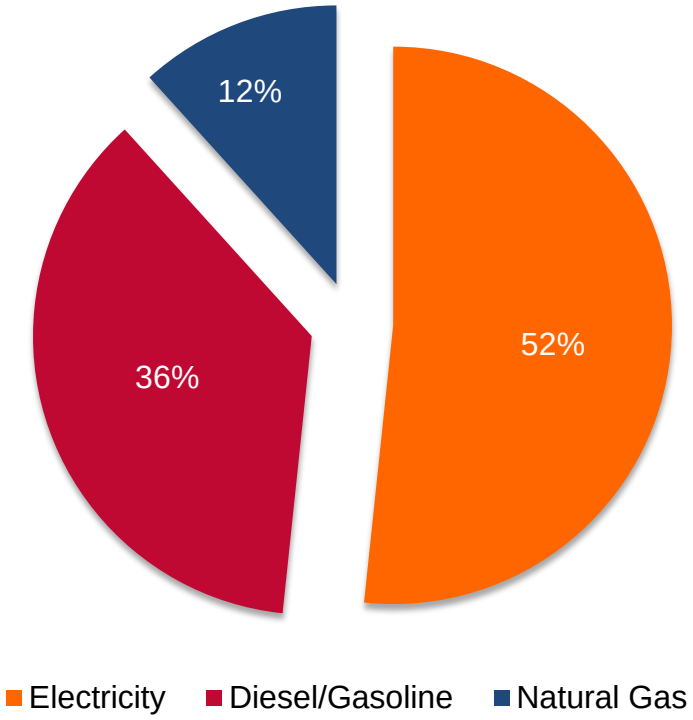


Figure 3 presents GHG emissions by energy type. Electricity and natural gas consumption by stationary sources produced 64% of all recorded GHG, with the vast majority – 52% – due to electricity consumption. Combustion of mobile fuels – diesel and gasoline – produced 36% of GHGs.

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



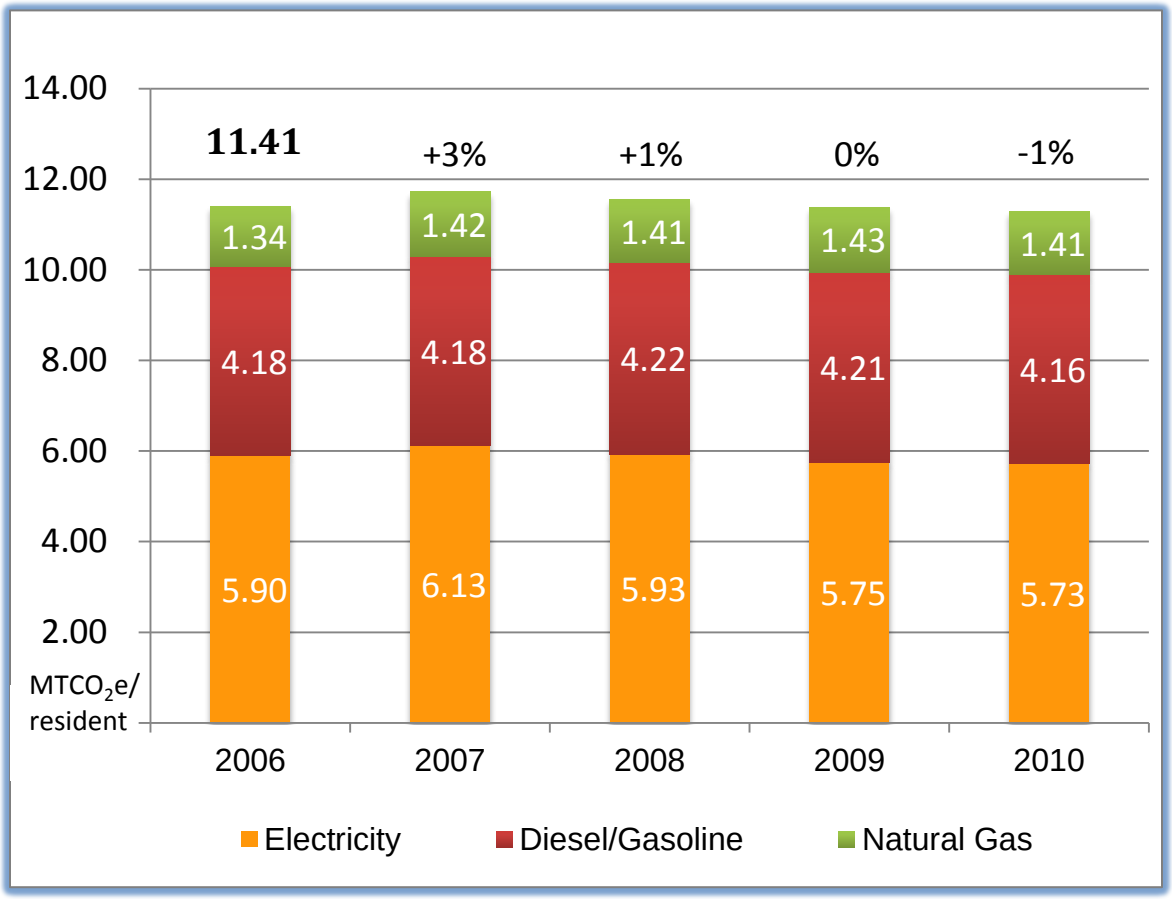
Communitywide, Fairfax County's total GHG emissions rose 3% from 2006 to 2010, per Table 1, below. Scope 1 – combustion within county boundaries – increased 2% in 2007, then an additional 1% in each following year. Thus, Scope 1 GHGs were 5% greater in 2010 than in 2006. Scope 2 – electricity consumption – 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.

2 EMISSIONS FROM STATIONARY SOURCES

2.1 Approach

Stationary sources are buildings, facilities, and residences. Energy is used to heat and produce electricity that is used by these stationary sources. Energy production by fossil fuels – coal, natural gas, propane and fuel oils – generates GHG emissions either directly, via combustion within the county (Scope 1), or indirectly, via the power grid (Scope 2).

Scope 1: GHGs from Combustion within the County

Natural gas is the predominant source of stationary Scope 1 emissions in Fairfax County. Only *de minimis* amounts of GHGs are produced by stationary combustion of other fossil fuels, such as fuel oil and propane. Natural gas is distributed within the county by two providers: Washington Gas (99.93%) and Columbia Gas (0.07%).[3]

The following two parameters were used to incorporate natural gas combustion into the community GHG inventory:

- Natural gas use was measured by customer consumption. Emissions related to transmission loss were excluded because they are outside the county's jurisdiction.
- GHG emissions per therm of natural gas use were determined using standard values in the Local Government Operations Protocol.

Scope 2: GHGs from Electricity Generation outside the County

Essentially all of the electricity that Fairfax County consumes is generated outside the county. Electricity is distributed within the county by two providers: Dominion Virginia Power (96%) and Northern Virginia Electric Company (4%).

Determining the GHG emissions related to electricity consumption relies on the use of factors because the interconnected nature of the electric grid makes it difficult to determine the precise blend of fossil, nuclear and renewable fuels used to produce electricity each year. As a result, the following two parameters were used for estimating electricity-related emissions:

[3] Washington Gas delivered annualized data for all years in therms, for which GHG emissions factors are readily available. By contrast, Columbia Gas provided only 2006 data, and in units of Million cubic feet (Mcf). Thus its data were converted using ratio 1 Mcf:10.27 therms. Columbia Gas data for subsequent years were estimated in proportion to its relative contribution to 2006 natural gas consumption in the county.

- Electricity use was measured by customer consumption. Emissions related to transmission loss were excluded because they are outside the county's jurisdiction.
- GHG emissions per kWh of power consumed each year are based on the United States Environmental Protection Agency's (EPA) inventory emission rate for the portion of the national electricity grid located in Virginia and the Carolinas.[4]

Annual electricity-to-GHG conversion factors (kWh to $MTCO_2e$) are presented in Appendix B, Table 7. For example, the table's conversion factor for 2006 indicates that each kWh of electricity consumed in Fairfax County created a byproduct of about 0.0005 $MTCO_2e$., which is about 1.1 pounds (0.5 kg) of CO_2e per kWh consumed.

Additional detail on the methods used to determine stationary GHG emissions is provided in Appendix B.

2.2 Results

Stationary sources produced over 7.4 million $MTCO_2e$ in 2006. As shown in Table 2, residential and commercial energy use generated the vast majority of emissions from stationary sources, with each accounting for 46% of stationary emissions.

Figure 5 provides the allocation by sector and energy type.

Table 2: 2006 Stationary GHG emissions by sector and energy use (% of total)

Sector	Electricity	Natural Gas	All Stationary Emissions
Commercial	42%	4%	46%
Residential	35%	12%	46%
Local Government	4%	1%	5%
Industrial	1%	2%	3%
All Stationary Emissions	**81%**	**19%**	**100%**

[4] The EPA has defined this area as the Southeastern Electric Reliability Council sub-region for Virginia/Carolina (SRVC).

Figure 5: 2006 stationary GHG emissions (in MTCO2e) by sector and energy use

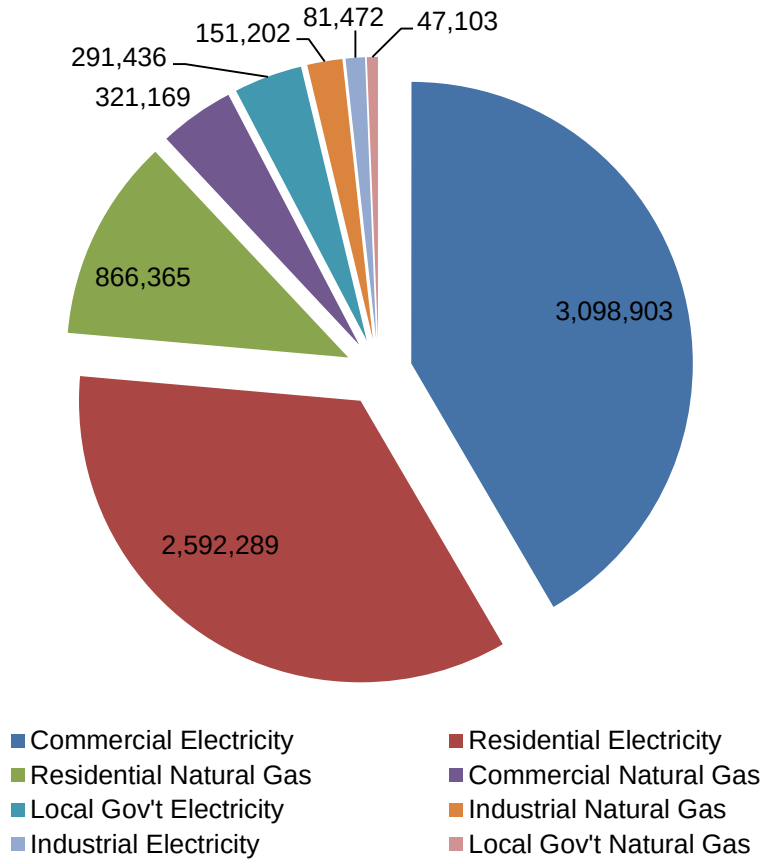


Table 2 also demonstrates that electricity is by far the biggest stationary energy use and GHG source for all sectors but industry. Three-fourths of residential GHGs came from electricity use, whereas 90% of commercial GHGs came from electricity use. Comprising only 5% of stationary emissions, county government GHGs also resulted mostly from electricity.

On a per capita basis, the county produced 7.18 MTCO2e from stationary energy use in 2006. Figure 6 and Table 3 depict how commercial and residential electricity consumption from stationary sources emitted 5.5 MTCO2e per person – nearly half of both stationary and mobile (total) GHGs – for the county that year.

Figure 6: 2006 stationary emissions per capita (in $MTCO_2e$)

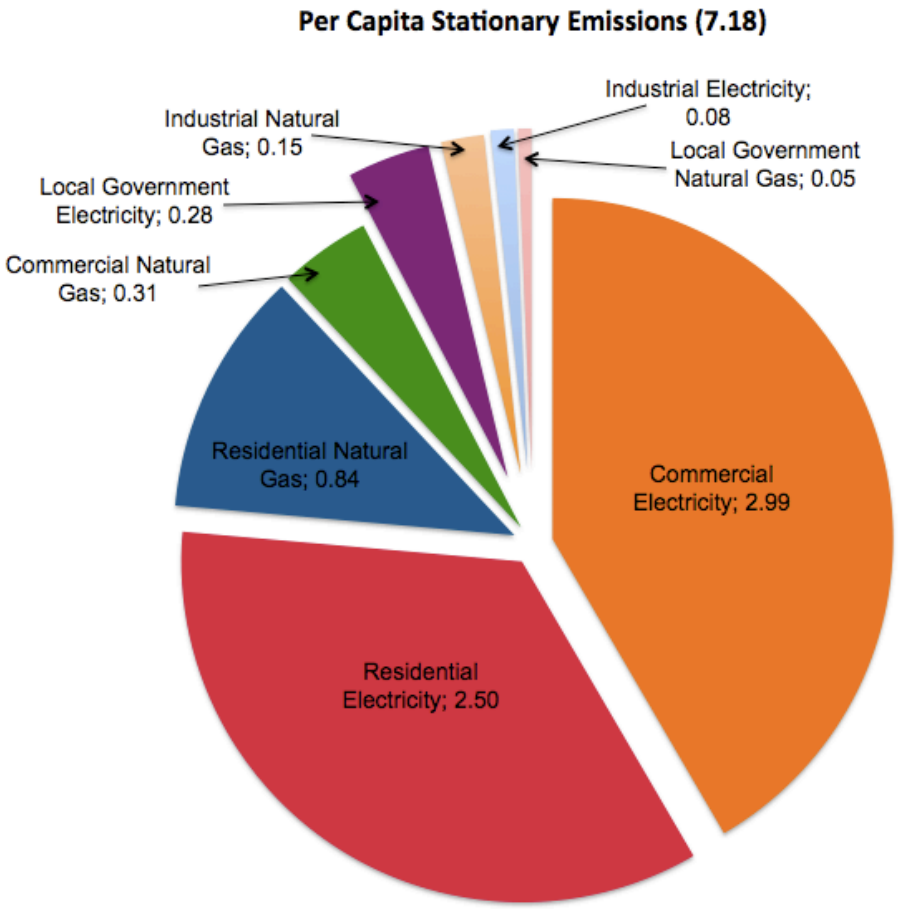


Table 3: 2006 stationary GHG emissions per resident, by sector and energy use

	$MTCO_2e$ per person		
Sector	**Electricity**	**Natural Gas**	**Total Emissions**
Commercial	2.99	0.31	3.30
Residential	2.50	0.84	3.33
Local Government	0.28	0.05	0.33
Industrial	0.08	0.15	0.22
Total	**5.85**	**1.34**	**7.18**

As presented in Appendix C.3, residential GHGs increased more than 7% over five years, from 3.46 million $MTCO_2e$ in 2006 to 3.72 in 2010. GHGs from county operations also increased by 5%, while commercial emissions declined by 1% and industrial emissions by 15%. By 2010, industrial emissions had dropped to only 0.19 million $MTCO_2e$.

3 EMISSIONS FROM MOBILE SOURCES

3.1 Approach

Mobile sources of GHG emissions include all manner of private and public on-road vehicles (e.g., sedans and SUVs), transportation (e.g., commuter trains) and off-road engines, vehicles and equipment (e.g., construction equipment and lawn mowers). Mobile GHG emitters may be either local (registered within the jurisdiction) or transient (passing through).

It is difficult to obtain definitive usage data for mobile source emissions in large part because fuel purchase and consumption is highly dispersed. All vehicles, whether local or transient, may release GHGs both within and outside the county's jurisdictional boundaries.

Three vehicle categories were considered for this GHG inventory:

1. *Local and transient on-road vehicles*, including passenger vehicles, light and heavy duty trucks, per vehicle class descriptions in Table 1 of Appendix B;

2. *Off-road engines, vehicles and equipment*, as defined and modeled by EPA, per categories described in Table 2 of Appendix B.

3. *Local trains with stations in the county*, specifically electric Metrorail rapid transit trains and diesel-powered VRE commuter trains.

Emissions related to local airports and major train stations were excluded as they exist outside the county's jurisdictional boundary. Other potential sources of mobile GHG emissions, such as commercial watercraft, were excluded as *de minimis*.

The methods described below aim to estimate annual fossil fuel consumption for each vehicle class or train type, then derive CO_2e using the conversion factor for that unit's energy type (Appendix B, Table 7). The inventory only considers the predominant energy use for a given vehicle, be it gasoline, diesel fuel or electricity.[5]

[5] Alternative fuel blends, such as E10, were not analyzed. Emissions associated with electric vehicles are reflected in the electricity consumption of the stationary unit where the vehicle is recharged.

Fuel consumption in gallons was determined indirectly as the quotient of annual vehicle miles traveled (AVMT) per vehicle class divided by its fuel economy (MPG). For the county government fleet, which is a subset of locally registered vehicles, direct fuel consumption was also recorded (Appendix C) but excluded from mobile calculations in order to prevent double accounting of emissions.

Over 940,000 vehicles are locally registered and their weight and/or year, make and model recorded by Fairfax County. In 2006, this local vehicle fleet was composed of 67% passenger vehicles, 33% light duty trucks and less than 1% heavy duty trucks.

MPG estimates for each vehicle class of locally registered vehicles is provided in Table 4. MPG from 2006 to 2010 improved only very slightly, no more than 0.3%, for all vehicle classes.

Table 4: MPG for locally registered on-road vehicle fleet, 2006-2010

Vehicle Type	2006	2007	2008	2009	2010
Passenger	28.3	28.3	28.3	28.3	28.3
Light Duty	20.8	20.8	20.9	20.9	21.1
Heavy Duty	5.5	5.5	5.5	5.5	5.5
Total Local Vehicles	**25.7**	**25.9**	**25.9**	**26.0**	**26.1**

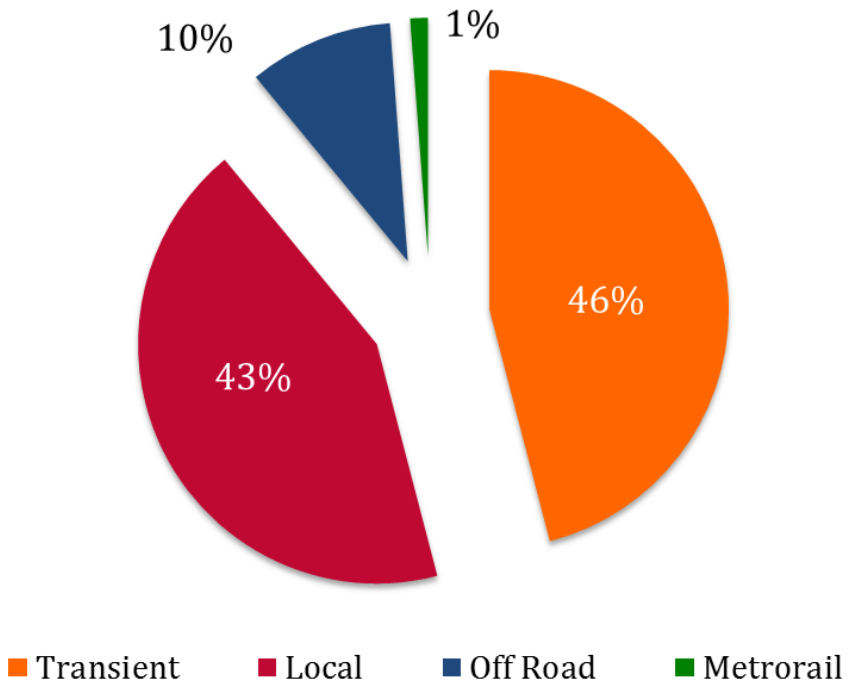
Integrating multiple agencies' survey data produced estimates of AVMT for both local and transient vehicles within each vehicle class, per methods in Appendix B.5.1. Over the five-year period, AVMT increased for both passenger vehicles and light duty trucks, and for both locally registered and transient fleets.

3.2 Results

Emissions from On-Road Vehicles (89%)

On-road vehicles accounted for 89% of mobile emissions in 2006, as shown in Figure 7. A slight majority of these vehicles were transient (46%), while the rest were locally registered (43%). Off-road engines, vehicles and equipment contributed 10% of GHGs and Metrorail 1%. VRE emissions of 0.04% were too small to register on this chart.

Figure 7: Distribution of mobile sources of GHG emissions in 2006



Mobile GHGs per resident were 4.23 MTCO2e, of which 1.94 came from transient and 1.82 from local vehicles. Transient and local vehicles each accounted for about one-sixth of the county's total 11.4 MTCO2e per resident.

Passenger vehicles dominated mobile emissions. As shown in Table 7, passenger vehicles created more GHGs than all other mobile units combined in both 2006 and later years. In second position, heavy duty trucks produced about one-fifth the GHGs as passenger vehicles, despite relatively tiny numbers and much lower AVMT. Slightly lower GHGs levels were created by light duty trucks and by off-road engines, vehicles and machinery.

Over the five-year period 2006-2010, GHG emissions increased from most mobile sources, with the exception of heavy duty trucks.

Table 5: AVMT by vehicle class and year, in million miles per year, 2006 - 2010

Vehicle Type	2006	2007	2008	2009	2010
Total Passenger	8,647	8,724	8,831	8,961	9,006
Total Light Duty	1,094	1,132	1,146	1,126	1,152
Total Heavy Duty	320	305	311	292	315
Total Vehicles	**10,061**	**10,161**	**10,287**	**10,379**	**10,473**
Transient Passenger	4,462	4,519	4,621	4,697	4,740
Transient Light Duty	565	586	600	590	606
Transient Heavy Duty	165	158	163	153	166
Total Transient	**5,192**	**5,263**	**5,383**	**5,440**	**5,512**
Local Passenger	4,185	4,205	4,209	4,264	4,266
Local Light Duty	529	546	546	536	546
Local Heavy Duty	155	147	148	139	149
Total Local	**4,869**	**4,898**	**4,904**	**4,939**	**4,961**

For purposes of converting fuel to GHG emissions, passenger vehicles and light duty trucks were considered to use gasoline, while heavy duty trucks used diesel fuel. These data were used to produce a fleet-wide average fuel economy for each vehicle class for both transient and local fleets. Table 6 illustrates fuel consumption for 2006.

Table 6: Fuel consumption by on-road vehicles in 2006, in million gallons

Vehicle Class	Gasoline (Million gallons)	Diesel (Million gallons)
All Vehicles		
Total Passenger	305	
Total Light Duty	53	
Total Heavy Duty		58
Total Vehicle	**358**	**58**
Transient		
Passenger	158	
Light Duty	27	
Heavy Duty		30
Total Transient	**185**	**30**
Local		
Passenger	148	
Light Duty	25	
Heavy Duty		28
Total Local	**173**	**28**

Emissions from Off-Road Engines, Vehicles and Equipment (10%)

Off-road sources were modeled using EPA software that provided only carbon dioxide emissions, not methane or nitrous oxide (14). Since off-road sources' contribution was small, and carbon dioxide comprises roughly 95% of combustion emissions for on-road vehicles, off-road methane and nitrous oxide emissions were dismissed as negligible (15). Appendix B provides technical detail on the methods used to derive GHG emissions from the above approach, including conversion factors.

Emissions from Rapid Transit and Commuter Trains (1%)

Railway emissions were determined using energy usage data provided by VRE and the Washington Metropolitan Area Transit Authority (WMATA), which operates Metrorail. VRE provided monthly systemwide diesel consumption data for its commuter trains. WMATA provided calendar year systemwide electricity usage for Metrorail rapid transit. The proportion of total VRE and Metrorail passengers residing in the county was estimated on a July-June fiscal year basis[6] in order to allocate a portion of these two systems' total energy usage to Fairfax County riders.

[6] Proportion of ridership attributable to Fairfax County residents in a calendar year was allocated the same value as ridership for the corresponding fiscal year (ending June 30). The proportion of train energy used by Fairfax residents while they were passengers outside the county was assumed to be equivalent to the proportion used by visitors while inside the county. Thus, local railway energy use was a proxy for use by both residents and visitors inside county boundaries.

Table 7: GHG emissions in Million $MTCO_2e$ by mobile source and year, 2006 – 2010

Source	2006	2007	2008	2009	2010
Total Vehicles					
Total Passenger	2.822	2.845	2.880	2.923	2.936
Total Light Duty	0.486	0.502	0.507	0.497	0.505
Total Heavy Duty	0.596	0.567	0.578	0.544	0.587
Total Vehicle	**3.905**	**3.914**	**3.965**	**3.964**	**4.028**
Transient Vehicles					
Passenger	1.456	1.474	1.507	1.532	1.545
Light Duty	0.251	0.260	0.265	0.261	0.266
Heavy Duty	0.308	0.294	0.302	0.285	0.309
Total Transient	**2.015**	**2.027**	**2.075**	**2.078**	**2.120**
Local Vehicles					
Passenger	1.366	1.371	1.373	1.391	1.391
Light Duty	0.235	0.242	0.242	0.237	0.239
Heavy Duty	0.288	0.273	0.275	0.259	0.278
Total Local	**1.890**	**1.886**	**1.890**	**1.886**	**1.908**
Local Rail					
Metrorail	0.053	0.052	0.050	0.048	0.054
VRE	0.002	0.004	0.005	0.004	0.004
Total Local Rail	**0.055**	**0.056**	**0.055**	**0.052**	**0.058**
Other Mobile Units					
Off-Road	0.429	0.438	0.448	0.458	0.468
Mobile Total	**4.388**	**4.408**	**4.467**	**4.474**	**4.554**

4 DISCUSSION

This inventory identified 11.8 million MTCO2e of GHG emissions resulting from community activities within the jurisdictional boundary of Fairfax County in 2006.

As shown in Table 8, direct (Scope 1) and indirect (Scope 2) energy emissions each accounted for about half of the total: 5.7 and 6.1 million $MTCO_2e$, respectively. Passenger vehicles literally drove on-road transportation to dominate Scope 1 emissions, at 3.9 Million MTCO2e. Residential natural gas use was a distant second at 0.9 million$MTCO_2e$. Electricity consumption by commercial (3.4) and residential (2.6) sectors accounted for nearly all Scope 2 emissions. These four GHG sources will likely be the most critical for county GHG managers to track and understand over time.

Table 8: Fairfax County GHG emissions inventory results

GHG Emissions Sources and Scope – Million MTCO2e	
Stationary Sources	2006
Residential Buildings	
Direct Emissions (Scope 1)	**0.9**
Energy Indirect Emissions (Scope 2)	**2.6**
Commercial/Institutional Facilities	
Direct Emissions (Scope 1)	**0.4**
Energy Indirect Emissions (Scope 2)	**3.4**
Industrial Energy Use	
Direct Emissions (Scope 1)	**0.2**
Energy Indirect Emissions (Scope 2)	**0.1**
Subtotal – All Stationary	**7.6**
Mobile Sources	
On-Road Transportation	
Direct Emissions (Scope 1)	**3.9**
Railways	
Direct Emissions (Scope 1)	**---**
Energy Indirect Emissions (Scope 2)	**0.1**
Off-Road	
Direct Emissions (Scope 1)	**0.4**
Subtotal – All Mobile	**4.4**
TOTAL	**11.8**

Passenger vehicles' GHG emissions increased 4% over the 2006 – 2010 time frame. The spatial pattern was not uniform, however: locally registered vehicles' emissions increased 2% while transient vehicles' GHGs rose 6%.

Residential electricity use also produced 6% more GHGs in 2010 than in 2006. Emissions from residents' natural gas grew more dramatically, over 13%. By contrast, GHGs from commercial electricity fell between 1 and 2% during this period.

The net impact of these changes was reported in Table 1. Scope 1 emissions increased steadily by 5% after 2006, while Scope 2 emissions remained within 1% of the 2006 baseline level. Hence, overall county emissions increased by around 3% by 2010. Still, population growth of 4% meant that county emissions per resident started to decline.

Subsequent years' GHG inventories should clarify whether or not this per capita decline indicates a new trend in energy efficiency and conservation. Either way, local population trends are an important consideration for tracking and anticipating the trajectory of GHG emissions over time.

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APPENDIX A: LIST OF ABBREVIATIONS

Acronym	Definition
AFOLU	Agriculture, Forestry and Other Land Uses
AVMT	Annual Vehicle Miles Traveled
Btu	British Thermal Units
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DVP	Dominion Virginia Power
E10	Fuel mixture of 10% ethanol and 90% gasoline
EIA	United States Energy Information Administration
EPA	United States Environmental Protection Agency
FCDOT	Fairfax County Department of Transportation
GGP	Greenhouse Gas Protocol
GHG	Greenhouse Gas
GRP	General Reporting Protocol (of the Climate Registry)
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
ICLEI	Local Governments for Sustainability
IEAP	International Local Government GHG Emissions Analysis Protocol
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt Hour
LGOP	Local Government Operations Protocol (of the Climate Registry)
LULUCF	Land Use, Land Use Change and Forestry
MPG	Miles per Gallon
MMT	Million Metric Tons (1 MMT = 10^9 kg)
MT	Metric Tons (1 MT = 1,000 kg)
MWCOG	Metropolitan Washington Council of Governments
N_2O	Nitrous Oxide
NOVEC	Northern Virginia Electric Company
PFCs	Perfluorocarbons
REC	Renewable Energy Credit
SF_6	Sulfur Hexafluoride
SRVC	Southeastern Electric Reliability Council sub-region for Virginia/Carolina
SUV	Sport Utility Vehicle
UNFCCC	United Nations Framework Convention on Climate Change
VDOT	Virginia Department of Transportation
VMT	Vehicle Miles Traveled
VRE	Virginia Railway Express
WMATA	Washington Metropolitan Area Transit Authority
WRI	World Resources Institute

APPENDIX B: METHODS AND CALCULATIONS

B.1 Methodological Standards

This Fairfax County Community GHG inventory consolidates two component research activities, the first for Fairfax County local government operations and the second for the broader non-governmental community (i.e., residential, commercial, industrial and transportation sectors).

Fairfax County created the government operations component using a set of standards evolved from the Greenhouse Gas Protocols (GGPs) for corporate and public sector organizations (8,16,17). In particular, the county closely followed direction of the Climate Registry (8) and its partners' GGP-compliant General Reporting Protocol (GRP) and its derivative Local Government Operations Protocol (LGOP), version 1.1 (2010).

The Community Greenhouse Gas Emissions Inventory Protocol (18) of the ICLEI was expected to provide a parallel framework for the second component of this project. However, at the time this report was completed, the protocol had not yet been finalized.[7] In the interim, ICLEI guided local governments to interpret and adapt its more general 2009 International Local Government GHG Emissions Analysis Protocol (IEAP) (7). Section 3.2.2, in particular, notes United Nations Framework Convention on Climate Change (UNFCCC) expectations that localities should report community emissions for the following sectors:

- Stationary Energy
- Transport
- Fugitive Emissions
- Industrial Processes
- Agriculture
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste

Certain sources that represent less than 5% of total CO_2e emissions meet *de minimis* criteria and may be excluded from measurement and reporting (7). Beyond Fairfax County's own operations, all sectors beyond Stationary Energy and Transport were deemed to meet *de minimis* criteria for reporting exclusion on an annual basis. (LULUCF may be more prominent when examined over multi-year to decadal periods of

[7] The ICLEI Community Greenhouse Gas Emissions Inventory Protocol was scheduled for completion in Spring 2012. Early drafts were requested, but not made available to the research team before the Fairfax County GHG inventory was completed.

change.) Beyond transient mobile emissions, IEAP-optional Scope 3 emissions were also omitted.

Beyond the general terms of the IEAP, the development of Fairfax County's first community GHG Emissions inventory pre-dated any communitywide tool or data processing guidance from nationally or internationally-recognized authorities.

In order to be consistent with the IEAP's Global Reporting Standard for comparative purposes, neighboring Arlington County previously adapted ICLEI's LGOP-compliant Clean Air & Climate Protection software to generate its own community GHG inventory (19). Arlington incorporated locally generated (IEAP Tier 2 and Tier 3) data accessible to both counties wherever feasible, otherwise defaulting to national-scale Tier 1 specificity (e.g., regarding vehicular MPG estimates) (2). Arlington officials advised Fairfax that repeating its customization of proprietary ICLEI software might not be the most prudent course of action. As a result, the GHG inventory development team opted to develop its own calculation spreadsheets from scratch.

The community portion of this inventory – residential, commercial, industrial and transportation sectors – is derived from Arlington County's methods. Any known deviations from this approach are either noted above this section or else explicitly identified below.

B.2 Hierarchal Classification for Types of Emissions

Data were classified into sectors and sources, following standard and readily accessible categorization schema used by utilities and tracking agencies. Energy types include electricity, natural gas, diesel fuel and gasoline. Figure B-1 shows top-level classes of sources as stationary and mobile. One tier below, sectors include residential, commercial, transportation, local government and industrial. (For simplicity, transportation includes mobile sources related to any other sector.)

Figure B-1: High-level categories used for the Fairfax County GHG inventory

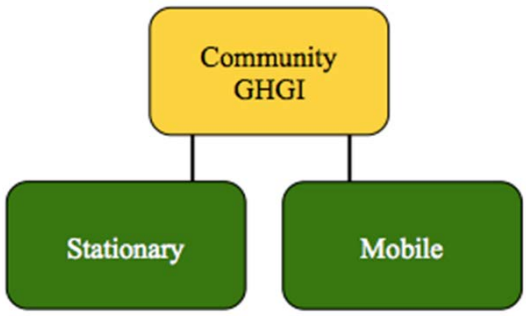
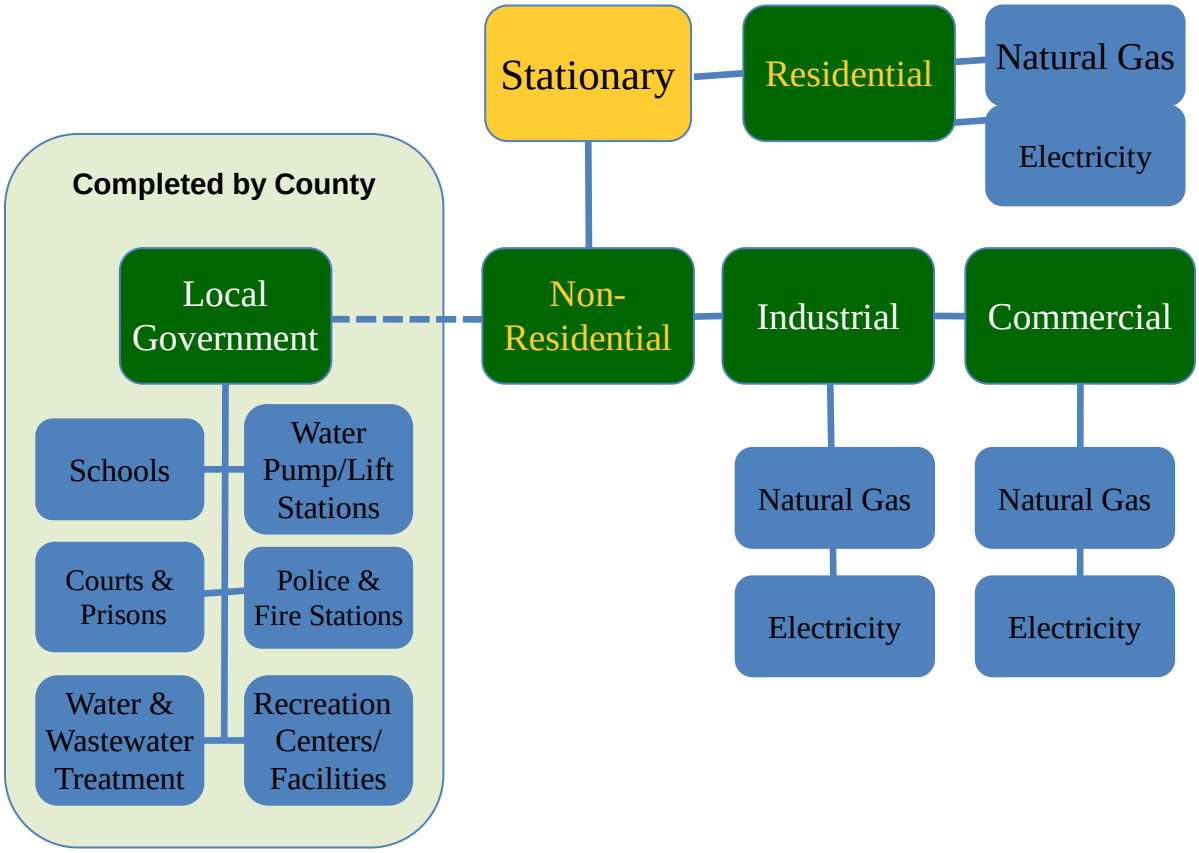


Figure B-2 presents primary categories for stationary emissions sources (residential and non-residential), along with sub-categories according to sector and energy type. Non-transportation fuel oil usage and livestock emissions were both deemed to be too small (<< 1%) to merit inclusion in the overall emissions for Fairfax County. Terms "Industrial," "Commercial" and "Residential" were defined per the Energy Information Agency (EIA) of the United States Department of Energy (10).

Figure B-2: Primary categories for stationary sources



As presented in Figure B-3, mobile emissions sub-categories include “local” vehicles that were registered in Fairfax County and “transient” vehicles that were not. Each includes a fleet of heavy duty trucks, light duty trucks and SUVs, and passenger vehicles and motorcycles. These vehicle classes reduced 13 federal functional classes to three (20), displayed in Table B-1. Note that local (registered in Fairfax County) vs. transient (registered elsewhere) could not be ascertained for off-road vehicles and are not applicable to Metrorail rapid transit and VRE commuter rail trains. County-owned passenger and transit fleets are implicitly included in this portion of the inventory, though explicitly listed under local government in Appendix C.

Figure B-3: Primary sub-categories for mobile category

While Fairfax County elected not to include pass-through transport via air or train tracks, emissions by county residents using Metrorail light rail and VRE commuter trains are included.

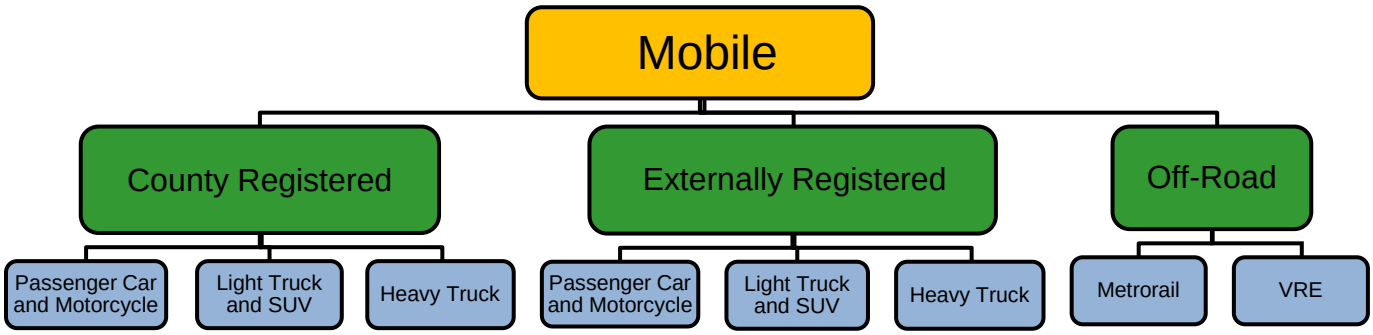


Table B-1: On-road vehicles by federal functional class, vehicle class and weight[8]

[8] County-registered vehicles of unknown make and model that weighed between 3,375 and 6,500 lbs. were assigned to vehicle classes of passenger or light duty truck using linear interpolation between these two values. Classes were based on EPA standards (http://www.fueleconomy;gov/feg/info/shtml). According to EPA's Test Car List Data Files (http://www.epa.gov/otaq/tcldata.html), Gross Vehicle Weight Rating (i.e., with passengers, called "ETW" by EPA) below 3,375 lbs. is always a passenger vehicle (class=0). Those above 6,500 and less than 10,000 are always [light] trucks (class=1). This was true for both 2006 and 2010 model years. For vehicles of intermediate weight (w), but unknown model type, we can linearly interpolate class (c) as follows: c = (w – 3,375) / (6,500 – 3,375), where c is in the

Federal Functional Class	Vehicle Classes	Weight of Vehicles
Motorcycles	Passenger	1 – 6,500 lbs.
Passenger Vehicles		
Two Axle, 4 Tire Single Unit Vehicles	Light duty truck	3,375 – 10,000 lbs.
Buses	Heavy duty truck	10,001+ lbs.
Two Axle, 6 Tire Single Unit Trucks		
Three Axle Single Unit Trucks		
Four or More Axle Single Unit Trucks		
Four Axle or Fewer Single Trailers		
Five Axle Single Trailers		
Six or More Axle Single Trailers		
Five Axle or Fewer Multi-Trailers		
Six Axle Multi-Trailers		
Seven or More Axle Multi-Trailers		

Off-road emissions classes – including off-road engines, equipment and vehicles – were estimated by EPA's NONROAD2008a model, the only readily available source for estimating off-road vehicular emissions for Fairfax County (14). This stand-alone tool does not provide estimates of quantity of (diesel or gasoline) fuel; hence it is not included in energy usage results (Appendix C.1 and C.2).

Table B-2 provides a list of off-road engines, vehicles and equipment for which emissions can be estimated at the county level using EPA's NONROAD2008a modeling tool

Table B-2: Off-road engines, vehicles and equipment with emissions estimated by EPA (14)

Off-Road Vehicles
Agricultural Equipment
Airport Support
Commercial Equipment
Construction Equipment

interval [0,1], representing the proportion of vehicles with known weight (w) that are expected to be passenger vehicles, and (1-c) the proportion expected to be light trucks. The known quantity (q) of all vehicles of a given weight under 6,500 lbs., but without make and model, that were classified as passenger vehicles was (q * c) and as light trucks (q * (1-c)).

Off-Road Vehicles
Industrial Equipment
Lawn & Garden Equipment
Logging Equipment
Oil Field Equipment
Railway Maintenance
Recreational Marine
Recreational Vehicle
Underground Mining

B.3 Data and Calculations

The basic model for determining GHG emissions for each usage type consists of first identifying their respective emission factors, i.e., how much GHG emissions – particularly metric tons (MT) of CO_2, CH_4 and N_2O – are produced per unit use of each resource (e.g., kWh of electricity, therms of natural gas, gallons of gasoline). This emission factor is then multiplied by a standard estimate of the Global Warming Potential (GWP) of that gas relative to CO_2, presented in units of metric tons CO_2 equivalent (MT CO_2e) in (1).

For instance, 1 therm of natural gas produces 5.31x10-3 MT of CO_2, 5.00x10-10 MT of CH_4 and $1.00x10^{-11}$ MT of N_2O. Multiplying each of these gas emissions by their respective GWP {1, 21, 310} results in {$5.31x10^{-3}$ $MTCO_2e$, $1.05x10^{-8}$ $MTCO_2e$, $3.10x10^{-9}$ $MTCO_2e$}, altogether slightly more than 0.00531 $MTCO_2e$ per therm of natural gas expended. This is the therm-to-CO_2e conversion factor for natural gas in this inventory.

Table B-7 provides some of the conversion factors for emissions considered in this inventory. (Upon request, the underlying spreadsheet is available for review.) Specific conversion factors used here include: therm to CO_2e, kWh to CO_2e, diesel to CO_2e, gasoline to CO_2e, ethanol to CO_2e, E10 gas to CO_2e, fuel oil to CO_2e and propane to CO_2e. (Due to variable fuel blends for electricity, kWh-to-CO_2e conversion factor is recalculated for each year.)

To determine the annual GHG emissions in $MTCO_2e$ for a given source and year, one calculates the product of the total quantity of that resource used (e.g., 73,547 therms used by Columbia Gas residential customers in 2006) and the conversion factor (0.00531 $MTCO_2e$/therm) to produce the results (e.g., 390 $MTCO_2e$ produced by those customers in 2006). These results divided by the county population for a given year provides the per capita GHG emissions.

B.4 Stationary Sources

Stationary emission sources include electricity and natural gas from residential, commercial and industrial sectors. The methodology to calculate emissions from these sources includes three steps:

B.4.1 Determine annual consumption of electricity and natural gas and, for local government operations only, stationary fuel oil.

B.4.2 Determine the appropriate CO_2, CH_4, and N_2O emission and conversion factors for electricity and natural gas.

B.4.3 Calculate emissions from electricity and natural gas.

The following sections (B.4.1-B.4.3) describe these steps in more detail.

B.4.1 Determine annual consumption of electricity and natural gas

Emissions resulting from electricity and natural gas were determined by using actual consumption data whenever possible. Annual consumption of residential, commercial and industrial electricity was provided by DVP, MWCOG and NOVEC. These data include gross consumption at point of meter, not inclusive of any transmission losses or Renewable Energy Credits (RECs, started by DVP in 2009). All data were received in MWh and kWh respectively. Table B-3 presents electricity consumption (in kWh) in Fairfax County from 2006 through 2010 by sector.

Table B-3: Total electricity usage (in kWh) by sector and year, 2006 – 2010

Type	2006	2007	2008	2009	2010
Commercial	5,925,905,138	6,153,587,240	6,096,775,760	5,919,452,368	5,976,199,142
Residential	4,957,128,372	5,234,984,703	4,985,215,444	4,985,809,019	5,366,142,672
Industrial	155,796,127	146,256,367	120,591,922	120,874,291	117,295,218
Local Government	557,301,768	565,734,851	568,933,533	559,968,145	580,165,555
Total	**11,596,131,405**	**12,100,563,161**	**11,771,516,659**	**11,586,103,823**	**12,039,802,587**

Annual consumption of residential, commercial and industrial natural gas was provided by Columbia Gas and Washington Gas. Natural gas includes gross in-county usage provided by Washington Gas and, for 2006, Columbia Gas.[9] Gross usage excludes any carbon offsets (started by Washington Gas in mid-2009) or transmission losses. All natural gas data were received in Mcf and therms respectively.[10]

Electricity and natural gas use by local government operations was provided directly by the county. Table B-4 presents natural gas consumption (in therms) in Fairfax County from 2006 through 2010 by sector.

Table B-4: Annual natural gas usage (in therms) by sector and year, 2006 – 2010

Sector	2006	2007	2008	2009	2010
Residential	163,279,747	177,504,347	178,656,732	181,608,585	185,393,179
Commercial	60,529,169	63,702,168	64,315,722	63,957,425	64,167,070
Industrial	28,496,373	26,588,025	24,024,929	26,225,554	25,749,351
Local Government	8,712,694	10,016,655	10,645,687	11,406,177	11,146,256
Total	**261,017,982**	**277,811,195**	**277,643,069**	**283,197,741**	**286,455,856**

The county also provided measures of its #2 fuel oil and propane usage, all of which were less than 4% of the county operations' total GHG emissions from stationary fuel usage (i.e., these fuel oils plus natural gas), per Table B-5. These emissions met the *de minimis* criterion (<5%) for exemption from reporting in a GHG inventory but were included in county operations for completeness. Since county use of these fuel oils met exemption requirements, extrapolating to other sectors would necessarily result in

[9] Natural gas consumption by Columbia Gas customers in 2007-2010 was estimated using the ratio of Columbia Gas-to-Washington Gas usage in 2006 multiplied by the usage by Washington Gas customers in subsequent years.

[10] Mcf was converted to therms by dividing by 10.27, per EIA estimates of average heat content per cf (13).

similar exemption. Thus, no further effort was made to estimate stationary fuel oil usage in other sectors, based on county operations values.

Table B-5: County operations' #2 fuel oil and propane usage (in gal.), 2006 - 2010.

Type	2006	2007	2008	2009	2010
#2 Fuel Oil	68,006	95,288	116,039	219,094	66,013
Propane	31,224	38,585	34,390	40,406	30,270
% of County stationary fuel GHG emissions	1.9%	2.2%	2.4%	3.9%	1.4%

B.4.2 Determine the appropriate CO_2, CH_4, and N_2O emission and conversion factors for electricity and natural gas

For electricity, the kWh-to-lb of CO_2 as well as kWh-to-lb of CH_4 and kWh-to-lb of N_2O emission factors vary year-to-year due to a transition to less GHG-polluting blend of energy sources, as shown in Table B-6. The county provided its standard emission factor, using the Inventory Emission Rate from 2006 eGRID using 2004 data, subregion SRVC, SERC Virginia/Carolina.

For natural gas, Mcf was converted to therms by multiplying by 0.09737 (13). The therm to CO_2e conversion factor (0.00530) is based on the LGOP (Version 1.1, May 2010).

Table B-6: Fairfax County CO_2, CH_4, and N_2O emission factors for stationary energy

Type	Units	2006	2007	2008	2009	2010
Electricity						
CO_2	MWh/lb	1,146.39	1,146.39	1,146.39	1,134.88	1,118.41
CH_4	MWh/lb	0.029	0.029	0.029	0.02377	0.02226
N_2O	MWh/lb	0.019	0.019	0.019	0.01979	0.01908
Natural Gas	Therm/CO_2e	0.0053	0.0053	0.0053	0.0053	0.0053

Note: Electricity factor from eGRID2010 Version 1.1, and natural gas factor from Climate Registry LGOP Version 1.1. The former decreased by approximately 1% in 2009 and 2010, due to the transition to less polluting energy sources for electricity (SAIC, personal communication).

Table B-7: Energy-to-MTCO$_2$e conversion factors used in this inventory

Energy Used	Units	Conversion Factor	Reference
Natural Gas	therms	0.005306	GWP in http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol ; GHG per therm in http://www.theclimateregistry.org/downloads/2010/05/2010-05-06-LGO-1.1.pdf
Electricity	kWh in 2006	0.000522942	GHG per kWh provided by Fairfax County, based on EPA's eGRID
Electricity	kWh in 2007	0.000522942	GHG per kWh provided by Fairfax County, based on EPA's eGRID
Electricity	kWh in 2008	0.000522942	GHG per kWh from Calendar 2008 GHG Inventory Emission Rate from 2006 eGRID using 2004 data, subregion SRVC, SERC Virginia/Carolina (http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2006V2_1_Summary_Tables.pdf)
Electricity	kWh in 2009	0.000517782	GHG per kWh from Calendar 2009 GHG Inventory Emission Rate from 2007 eGRID using 2005 data, subregion SRVC, SERC Virginia/Carolina; see http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year05_SummaryTables.pdf
Electricity	kWh in 2010	0.000510197	GHG per kWh from Calendar 2010 GHG Inventory Emission Rate from 2010 eGRID using 2007 data, subregion SRVC, SERC Virginia/Carolina; see http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_1_year07_SummaryTables.pdf
Diesel	gallons	0.01030278	GHG per gallon, from http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/
Gasoline	gallons	0.009242105	GHG per gallon, calculated as 100/95 of gasoline-to-CO_2 ratio, per http://www.epa.gov/oms/climate/420f05004.htm. I.e., assumes CO_2 comprises 95% of vehicular emissions, then multiplies accordingly by 100/95 per EPA to get CO_2e.
Ethanol	gallons	0.0058287	GHG per gal from http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/
E10	gallons	0.008900765	calculated as 90% gasoline + 10% ethanol
Fuel Oil	gallons	0.010229236	GHG per gallon provided by Fairfax County.
Propane	gallons	0.00570462	GHG per gallon provided by Fairfax County.

B.4.3 Calculate emissions from electricity and natural gas

Using conversion factors as the sum across all GHGs of the product of emissions factors for that GHG times its GWP:

CO_2 Emissions (metric tons **CO_2**e) = **CO_2** Emissions (metric tons) x 1 (GWP)

CH_4 Emissions (metric tons **CO_2**e) = **CH_4** Emissions (metric tons) x 23 (GWP)

N_2O Emissions (metric tons **CO_2**e) = **N_2O** Emissions (metric tons) x *296 (GWP)*

With conversion factors in Table 7, the following equations were used to calculate total emissions:

Emissions (MT CO_2e) = kWh of electricity consumed × electricity conversion factor

Emissions (MT CO_2e) = therms of natural gas used × natural gas conversion factor

B.5 Mobile Sources

Mobile emissions incorporated local and transient on-road vehicles, off-road vehicles, rapid transit and commuter rail. Methods for determining the energy use and GHG emissions for each are presented below. The approach paralleled that for stationary sources:

B.5.1 Determine annual consumption of energy by on-road vehicles, rapid transit and commuter trains.

B.5.2 Determine the appropriate CO_2, CH_4, and N_2O emission and conversion factors for diesel and gasoline.

B.5.3 Calculate GHG emissions from vehicles and trains.

B.5.4 Estimate CO_2 from off-road vehicles and machines.

The following sections (B.5.1-B.5.4) describe these steps in more detail.

B.5.1 Determine annual consumption of energy by on-road vehicles, rapid transit and commuter trains

Distinct methods were used to determine energy consumption for each of on-road vehicles, Metrorail rapid transit and VRE commuter trains, as follows:

On-road vehicles

Fuel consumption (in gallons) by an on-road vehicle equals its distance traveled (in miles) divided by its fuel economy (MPG). That is:

Fuel consumption (in gal.) = AVMT (in miles) / fuel economy (as MPG)

Estimating fuel consumption across over a million vehicles – motorcycles, passenger vehicles and trucks registered in or traveling to Fairfax County – each year required counting and aggregating vehicles into vehicle classes, then determining MPG per vehicle class. Counts and MPG by vehicle class, in turn, served as inputs to calculate vehicle class-weighted, fleet-wide MPG (the denominator for fuel consumption). Finally, annual vehicle miles traveled (AVMT) was estimated for both county-registered and transient vehicles, their sum serving as the numerator for total fuel consumption.

Counting and classifying vehicles: Fairfax County provided aggregated registration data for over 940,000 vehicles residing in the county each year. Counts of vehicles by year, make and model for each registration year were categorized into three categories: passenger vehicle, light duty truck and heavy duty truck. Table B-1 presents how these vehicle classes consolidate federal functional classes.

Myriad registered vehicles were not recorded by year, make and model – from 137,000 in 2006 to over 330,000 by 2010. Instead, vehicle weights provided for all vehicles registered in 2010 were used to classify these unknown vehicles into vehicle classes (see footnote 9). The relative proportion of unknown vehicles in each vehicle class in 2010 was applied to similarly categorize unknown vehicles from prior years (for which vehicle weight was also unavailable) by vehicle class.

The result was a county-registered fleet comprised of about 69% passenger vehicles, 30% light duty trucks and 1% heavy duty trucks.

Determining vehicle class and fleet-wide MPG: Based on EPA's average MPG for both city and highway combined (http://www.fueleconomy.gov/feg/download.shtml), average MPG was estimated according to vehicles' model, year and class for each vehicle registration year.

Weighted MPG for each vehicle class for a particular production year was calculated as the product of the total number of vehicles for that model year and its corresponding average MPG. Summing weighted MPG across all model years provided an age-weighted MPG for each vehicle class, in each registration year. Average fuel economy for passenger vehicles (28.3 MPG) and heavy duty trucks (5.5 MPG) did not vary across 2006-2010 registration years; however, light trucks improved by 0.3 MPG (from 20.8 to 21.1). Weighting these MPG values by relative vehicle prevalence in the county, fleet-wide MPG rose from 25.7 to 26.1 during the five-year study period.

Estimating annual vehicle miles traveled: AVMT in Fairfax County was calculated using an annual road segment survey data from VDOT and interpolated from a 2005 and 2010 household survey data from MWCOG. The maximum of the two sources in a given year was used as the AVMT for this inventory.

VDOT – but not MWCOG – distinguished vehicle classes and Fairfax County from the jurisdictions it surrounds (Fairfax City and Falls Church). Hence MWCOG data were corrected for the proportion of VDOT miles across these three jurisdictions that was attributable to travel in the county alone. Furthermore, VDOT vehicle proportions were used to allocate AVMT by vehicle class. Meanwhile, MWCOG provided AVMT per household[11] which, when multiplied by the number of county households,[12] provided an estimate of AVMT by county-registered vehicles (vs. transient vehicles).

For each year, total AVMT within Fairfax County for the federal functional vehicle class was derived from daily means on the VDOT website (http://www.virginiadot.org/info/ct-TrafficCounts.asp). AVMT for Fairfax City and City of Falls Church was also obtained in order to determine their ratio of AMVT compared with Fairfax County. In addition, VDOT's AVMT data by federal functional class was consolidated into vehicle classes.

The following provides an example of this computation process. VDOT's 2006 daily vehicle miles traveled (VMT) for motorcycles in Fairfax County (59,630) was summed with passenger vehicles daily VMT (22,061,211) to determine the daily VMT attributable to passenger vehicles (85.9%) in 2006. Annualizing and summing with other vehicles' corresponding data determines the total VDOT estimate for 2006 AVMT (25,738,260 miles/day, 9,394 mega-miles/yr). MWCOG's estimated AVMT for all vehicle types[13] across the three jurisdictions (10,322 mega-miles/yr in 2006) was adjusted by the VDOT

[11] See http://www.mwcog.org/uploads/committee-documents/bF5cWV5Y20090415144559.ppt

[12] The Fairfax County website includes annual estimates of number of households and (for per capita calculations) residents at http://www.fairfaxcounty.gov/demogrph/gendemo.htm.

[13] MWCOG GHGI staff confirmed (July 2011) that MWCOG survey accounted for all vehicle classes.

proportion of AVMT attributable to trips within the county (10,061 mega-miles/yr). In 2006, county households' AVMT (4,869 mega-miles/yr for all county-registered vehicles) was calculated at 48.4% of total AVMT. This inventory's AVMT was the maximum of VDOT and MWCOG estimates, which for 2006 is 10,061 mega-miles/yr.

In all study years, MWCOG AVMT was greatest, while VDOT data helped to apportion AVMT by vehicle class. Thus, vehicle class and fleet-wide fuel consumption was determined as the MWCOG-derived county-wide AVMT divided by fleet-wide MPG for each study year.

Accounting for county-owned vehicles: Neither MWCOG nor VDOT estimates of countywide AVMT distinguished county-owned vehicles from those of the public-at-large. Nonetheless, the county directly calculated its vehicles' energy consumption. As a result, county vehicles were included in energy and emissions results for both the transportation sector and county operations, then subtracted from overall emissions calculations to prevent double counting.

Metrorail rapid transit and VRE commuter rail

Fairfax County's portion of electricity use for Metrorail rapid transit was estimated using the proportion of all Metrorail riders residing in the county multiplied by system-wide electricity use. WMATA provided total systemwide electricity use.

Similarly, commuter rail diesel fuel use was determined as a function of the proportion of all VRE riders residing in the county multiplied by systemwide diesel fuel use. Virginia Railroad Express (VRE) supplied its monthly systemwide diesel fuel usage.

The Fairfax County Department of Transportation (FCDOT) delivered ridership values on a fiscal year basis. (The fiscal year ended June 30 of the corresponding calendar year.) However, neither FCDOT nor WMATA nor VRE provided calendar year ridership. Thus, fiscal year was used as the best feasible proxy for calendar year.

B.5.2 Determine the appropriate CO_2, CH_4, and N_2O emission for diesel and gasoline

From LGOP version 1.1 (3), CO_2 emissions per gallon of diesel or gasoline fuel are presented as emission factors in Table B-8. The corresponding factors for diesel fuel CH_4 and N_2O are 6×10^{-7} and 3×10^{-7} kg/gallon, respectively – less than a millionth that of CO_2. Hence, even when factoring in the high GWP of these secondary byproducts, the diesel-to-CO_2e conversion factor is dominated by its CO_2 component.

EPA has recommended that CO_2 represent 95% of all GHG emissions for gasoline.[14] Using this multiplier, no additional emission factors needed to be calculated for CH_4 or N_2O.

Table B-8: Mobile CO_2 emission factor (in kg/gallon), by fuel type[15]

Fuel Type	Applicable Vehicles	CO_2 Emission Factor
Diesel	Heavy duty trucks, VRE commuter rail	10.084
Gasoline	Passenger vehicles, light duty trucks	8.788

B.5.3 Calculate GHG emissions from vehicles and trains

Metrorail electricity use in Fairfax County was converted to GHG emissions by multiplying the amount (in kWh) by the same annual conversion factors as for electricity as a whole, as shown in Table B-7). Emissions associated with passenger vehicles and light duty trucks similarly derived from the corresponding Table B-7 conversion factor for gasoline to CO_2e. GHG emissions from VRE commuter rail and heavy duty trucks were calculated by multiplying the amount (in gallons) of diesel fuel usage per year by the diesel-to-CO_2e conversion factor in the same table.

B.5.4 Estimate CO_2 from off-road vehicles and machines

Off-road emissions include CO_2 emissions from the sources listed in Table B-2: agricultural equipment; airport support; commercial equipment; construction equipment; industrial equipment; lawn & garden equipment; logging equipment; oil field equipment; railway maintenance; recreational marine; recreational vehicle; and underground mining.

These emissions were obtained from EPA NONROAD2008a model (with 2009-2010 based on 2008 model estimates, which is latest update) for Fairfax County (locality number 51059). This only provides CO_2 emissions, however, so other GHGs' magnitudes were not able to be directly estimated. Given the relatively tiny contribution of off-road CO_2, the contribution of other non-road GHGs was deemed inconsequential and thus exempt from reporting.

[14] Source: http://www.epa.gov/oms/climate/420f05004.htm

[15] Source: http://www.epa.gov/oms/climate/420f05001.htm

APPENDIX C: ENERGY USAGE AND EMISSIONS BY SECTOR AND YEAR

Appendix C presents the entirety of this inventory's outputs by both energy type and GHG emissions by sector and year. Tables C-1 and C-2 provide energy consumption data on a total basis and a per-capita basis. Note regarding energy use follow Table C-2. Tables C-3 and C-4 provide emissions data on a total basis and a per-capita basis. Notes regarding emissions follow Table C-4.

Table C-1: Total energy use by sector and year

Sector	Note	Unit	2006	2007	2008	2009	2010
Residential Electricity	1	kWh	4,957,128,372	5,234,984,703	4,985,215,444	4,985,809,019	5,366,142,672
Residential Natural Gas	2	therms	163,279,747	177,504,347	178,656,732	181,608,585	185,393,179
Commercial Electricity	1	kWh	5,925,905,138	6,153,587,240	6,096,775,760	5,919,452,368	5,976,199,142
Commercial Natural Gas	2	therms	60,529,169	63,702,168	64,315,722	63,957,425	64,167,070
Industrial Electricity	1	kWh	155,796,127	146,256,367	120,591,922	120,874,291	117,295,218
Industrial Natural Gas	2	therms	28,496,373	26,588,025	24,024,929	26,225,554	25,749,351
Passenger Vehicle		gal	305,376,116	307,799,734	311,644,222	316,256,977	317,692,893
Light Duty Vehicle		gal	52,618,830	54,337,129	54,845,426	53,782,240	54,617,933
Heavy Duty Vehicle		gal	57,839,827	55,006,601	56,077,960	52,826,451	57,008,544
County-based Passenger Vehicle		gal	147,794,030	148,366,225	148,557,799	150,499,497	150,490,148
County-based Light Duty Vehicle		gal	25,466,134	26,191,689	26,144,286	25,593,744	25,872,347
County-based Heavy Duty Vehicle		gal	27,992,959	26,514,389	26,731,823	25,138,906	27,004,772
External Passenger Vehicle		gal	157,582,086	159,433,509	163,086,423	165,757,480	167,202,745
External Light Duty Vehicle		gal	27,152,696	28,145,441	28,701,140	28,188,496	28,745,586
External Heavy Duty Vehicle		gal	29,846,868	28,492,213	29,346,137	27,687,545	30,003,772
Off-Road Vehicle	7	gal	n.a.	n.a.	n.a.	n.a.	n.a.

Sector	Note	Unit	2006	2007	2008	2009	2010
Metrorail		kWh	100,620,946	100,174,219	94,978,664	93,209,842	106,120,192
Commuter Rail		gal	174,100	352,765	463,823	367,575	375,165

Sector	Note	Unit	2006	2007	2008	2009	2010
County Operations-Electricity	3,4	kWh	557,301,768	565,734,851	568,933,533	559,968,145	580,165,555
County Operations-Direct Combustion … Natural Gas	3,4	therms	8,712,694	10,150,528	10,796,115	11,665,677	11,242,539
County Operations-Direct Combustion … #2 Fuel Oil	3,4,6	gal	68,006	95,288	116,039	219,094	66,013
County Operations-Direct Combustion … Propane	3,4	gal	31,224	38,585	34,390	40,406	30,270
County Operations-Mobile	3,5	gal	87,110	87,116	94,348	100,499	102,754

Table C-2: Per capita energy use by sector and year

Sector energy, per capita	Note	2006	2007	2008	2009	2010
Residential Electricity	7	4,778.83	5,026.36	4,767.38	4,739.41	4,964.04
Residential Natural Gas	7	157.41	170.43	170.85	172.63	171.50
Commercial Electricity	7	5,712.76	5,908.35	5,830.36	5,626.91	5,528.38
Commercial Natural Gas	7	58.35	61.16	61.51	60.80	59.36
Industrial Electricity	7	150.19	140.43	115.32	114.90	108.51
Industrial Natural Gas	7	27.47	25.53	22.98	24.93	23.82
Passenger	7	294.39	295.53	298.03	300.63	293.89
Light Duty	7	50.73	52.17	52.45	51.12	50.53
Heavy Duty	7	55.76	52.81	53.63	50.22	52.74
County-based Passenger	7	142.48	142.45	142.07	143.06	139.21
County-based Light Duty	7	24.55	25.15	25.00	24.33	23.93
County-based Heavy Duty	7	26.99	25.46	25.56	23.90	24.98
External Passenger	7	151.91	153.08	155.96	157.57	154.67
External Light Duty	7	26.18	27.02	27.45	26.80	26.59
External Heavy Duty	7	28.77	27.36	28.06	26.32	27.76
Off-Road	8	n.a.	n.a.	n.a.	n.a.	n.a.
Commuter Rail	7	0.17	0.34	0.44	0.35	0.35
Metrorail	7	97.00	96.18	90.83	88.60	98.17
County Operations-Electricity	7	537.26	543.19	544.07	532.29	536.69

Sector energy, per capita	Note	2006	2007	2008	2009	2010
County Operations-Direct Combustion Wash. Gas	7	8.40	9.75	10.32	11.09	10.40
County Operations-Direct Combustion #2 Fuel Oil	7	0.07	0.09	0.11	0.21	0.06
County Operations-Direct Combustion Propane	7	0.03	0.04	0.03	0.04	0.03
County Operations-Mobile	7	0.08	0.08	0.09	0.10	0.10

NOTES REGARDING ENERGY USE:

1. Electricity is gross in-county usage provided by DVP and NOVEC at the meter and does not account for transmission loss or any Renewable Energy Credits (RECs, started by DVP in 2009).

2. Natural gas includes net in-county usage provided by Washington Gas and Columbia Gas (2006 only) at the meter and does not account for transmission loss or any carbon offsets (started by Washington Gas in 2011).

3. County operations include county schools' operations and county-operated bus transit. Each also includes both stationary and mobile emissions.

4. Stationary component of county operations is not included in other sectors' stationary usage.

5. Mobile component of county operations is included in communitywide mobile inventory, thus is not double counted here.

6. A factor of three variations in #2 fuel oil usage across years can be explained by intentional decision to use up existing supplies,

7. Per capita data calculated by dividing total emissions by the county's population estimates, with energy units per Annex C.1:

2006	2007	2008	2009	2010
1,037,311	1,041,507	1,045,694	1,051,990	1,081,004

8. Off-road vehicular emissions were calculated without direct access to underlying energy usage, also without any specific inputs from our research team, per EPA's NONROAD2008a model (9).

Table C-3: Total GHG emissions by sector and year in $MTCO_2e$

Sector	Note	2006	2007	2008	2009	2010
Total Emissions (in $MTCO_2e$)	1	**11,838,076**	**12,210,986**	**12,097,494**	**11,978,115**	**12,217,349**
Residential Electricity	2	2,592,289	2,737,592	2,606,977	2,581,563	2,737,791
Residential Natural Gas	3	866,365	941,840	947,955	963,618	983,699
Commercial Electricity	2	3,098,903	3,217,967	3,188,258	3,064,986	3,049,040
Commercial Natural Gas	3	321,169	338,005	341,260	339,359	340,471
Industrial Electricity	2	81,472	76,484	63,063	62,587	59,844
Industrial Natural Gas	3	151,202	141,076	127,477	139,153	136,626
Passenger		2,822,318	2,844,718	2,880,249	2,922,880	2,936,151
Light Duty		486,309	502,189	506,887	497,061	504,785
Heavy Duty		595,911	566,721	577,759	544,259	587,346
County-based Passenger		1,365,928	1,371,216	1,372,987	1,390,932	1,390,846
County-based Light Duty		235,361	242,066	241,628	236,540	239,115
County-based Heavy Duty		288,405	273,172	275,412	259,001	278,224
External Passenger		1,456,390	1,473,501	1,507,262	1,531,948	1,545,305
External Light Duty		250,948	260,123	265,259	260,521	265,670
External Heavy Duty		307,506	293,549	302,347	285,259	309,122
Off-Road		429,187	438,185	447,775	457,665	467,600
Metrorail		52,619	52,385	49,668	48,262	54,142
Commuter Rail		1,794	3,634	4,779	3,787	3,865
County Operations	4	425,649	437,306	449,736	453,434	458,743
County Operations-Stationary	5	338,540	350,190	355,388	352,934	355,989
County Operations-Electricity	5	291,436	295,846	297,519	289,941	295,999
County Operations-Direct Combustion	5	47,103	54,343	57,869	62,993	59,990
County Operations-Mobile	6	87,110	87,116	94,348	100,499	102,754

Table C-4: Per capita GHG emissions by sector and year

Sector	Note	2006	2007	2008	2009	2010
Total Emissions (in $MTCO_2e$ per capita)		***11.41***	***11.72***	***11.57***	***11.39***	***11.30***
Residential Electricity per capita	7	2.50	2.63	2.49	2.45	2.53
Residential Natural Gas per capita	7	0.84	0.90	0.91	0.92	0.91
Commercial Electricity per capita	7	2.99	3.09	3.05	2.91	2.82
Commercial Natural Gas per capita	7	0.31	0.32	0.33	0.32	0.31
Industrial Electricity per capita	7	0.08	0.07	0.06	0.06	0.06
Industrial Natural Gas per capita	7	0.15	0.14	0.12	0.13	0.13
Passenger per capita	7	2.72	2.73	2.75	2.78	2.72
Light Duty per capita	7	0.47	0.48	0.48	0.47	0.47
Heavy Duty per capita	7	0.57	0.54	0.55	0.52	0.54
County-based Passenger per capita	7	1.32	1.32	1.31	1.32	1.29
County-based Light Duty per capita	7	0.23	0.23	0.23	0.22	0.22

Sector	Note	2006	2007	2008	2009	2010
County-based Heavy Duty per capita	7	0.28	0.26	0.26	0.25	0.26
External Passenger per capita	7	1.40	1.41	1.44	1.46	1.43
External Light Duty per capita	7	0.24	0.25	0.25	0.25	0.25
External Heavy Duty per capita	7	0.30	0.28	0.29	0.27	0.29
Off-Road per capita	7	0.41	0.42	0.43	0.44	0.43
Metrorail per capita	7	0.05	0.05	0.05	0.05	0.05
Commuter Rail per capita	7	0.00	0.00	0.00	0.00	0.00
County Operations per capita	7	0.41	0.42	0.43	0.43	0.42
County Operations-Stationary per capita	7	0.33	0.34	0.34	0.34	0.33
County Operations-Electricity per capita	7	0.28	0.28	0.28	0.28	0.27
County Operations-Direct Combustion per capita	7,8	0.05	0.05	0.06	0.06	0.06
County Operations-Mobile per capita	9	0.08	0.08	0.09	0.10	0.10

NOTES REGARDING EMISSIONS:

1. County mobile operations are omitted from total GHG emissions to prevent double counting as part of total mobile units' emissions.

2. Electricity is gross in-county usage provided by DVP and NOVEC at the meter, and does not account for transmission loss or any Renewable Energy Credits (RECs, started by DVP in 2009).

3. Natural gas includes net in-county usage provided by Washington Gas and Columbia Gas (2006 only) at the meter, and does not account for transmission loss or any Carbon offsets (started by Washington Gas in 2011).

4. County operations include county schools' operations and county-operated bus transit. Each also includes both stationary and mobile emissions.

5. Stationary component of county operations is not included in other sectors' stationary usage.

6. Mobile component of county operations is included in community-wide mobile portion of inventory, thus is not double counted here.

7. Per capita data calculated by dividing total emissions by the county's population estimates:

2006	2007	2008	2009	2010
1,037,311	1,041,507	1,045,694	1,051,990	1,081,004

8. While county operations include stationary fuel oil and propane emissions, the broader community's stationary fuel oil and propane emissions were not calculated due to expected minor (<2% of total) contribution and difficulty in obtaining accurate data.

9. Mobile component of county operations is included in community-wide mobile portion of the inventory, thus is not double counted here.