Final Report

Baltimore County Government

Greenhouse Gas Inventory 2002 – 2006

Projections for 2012

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Executive Summary

Overview of the Assignment

I conducted Inventories of Greenhouse Gases (GHGs) for Baltimore County and for County Government operations using The Clean Air and Climate Protection (CACP) Software developed by Torrie Smith Associates for the International Council for Local Environmental Initiatives.

The years inventoried for Baltimore County and County Government were 2002 to 2006, and projections were made for the emissions based on business as usual (BAU) for 2012. Targets for 10% reduction of the base year (2006) emissions by 2012 were based on the recently released Maryland Climate Action Plan. Scenarios for emissions reductions were run, and comparisons to other jurisdictions were made. The inventory and projections focused on Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), the most common of the six Kyoto gases emitted in the US. Emissions are expressed in metric tons of equivalent CO_2, a commonly used aggregate of total GHG emissions.

Methodology

CACP Software organizes the Community Analysis into six sectors – Residential, Commercial, Industrial, Transportation, Waste and Other. The key pieces of data needed are energy consumption, Vehicle Miles Traveled (VMT), and the total amount of solid waste generated. The Government Analysis is organized in seven sectors – Buildings, Vehicle Fleet, Employee Commute, Streetlights, Waste Water, Solid Waste and Other. Data needed are similar to and a subset of the Community data.

Results

Presented below are County Government results by **Source** and then by **Sector**. The Community results are then presented. Government emissions represent 1.2% of the Community GHGs. Lastly, the Maryland Climate Action Plan Targets for Reductions are presented as markers for performance.

Figure 1 County Government GHG Emissions by Source, 2006

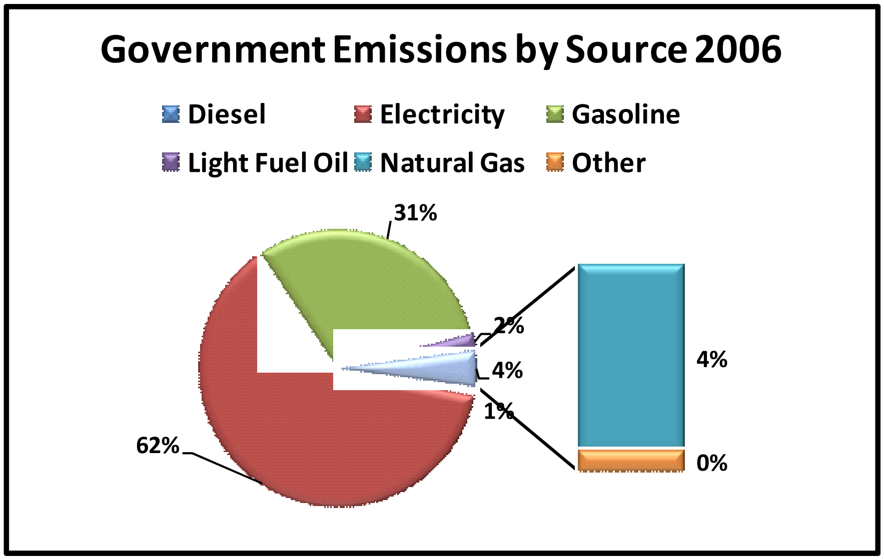

Table 1 County Government GHG Emissions by Sector, 2002 – 2006, and 2012

Year	*2002*	*2003*	*2004*	*2005*	*2006*	*Projections 2012*
Buildings	38,995	39,588	39,836	40,234	39,629	40,893
Vehicle Fleet	20,537	18,659	19,208	19,553	20,162	20,411
Staff Commute	24,649	24,770	24,697	24,741	24,820	25,188
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Waste	558	563	565	568	572	585
Metric Tons eCO2	**149,802**	**144,729**	**148,913**	**145,327**	**142,701**	**148,258**

Figure 2 Community GHG Emissions by Source, 2006

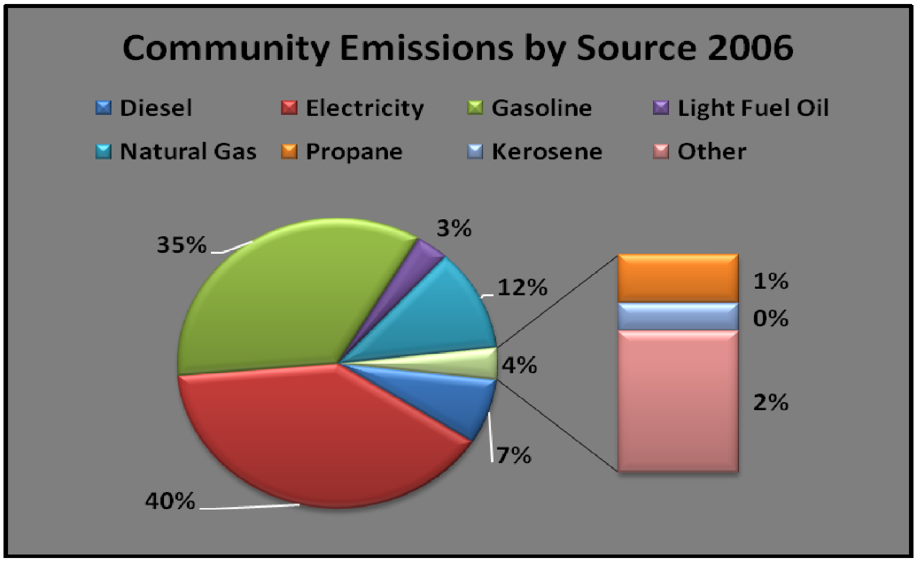

Table 2 Community GHG Emissions by Sector, 2002 -2006, and 2012

Year	*2002*	*2003*	*2004*	*2005*	*2006*	*Projections 2012*
Residential	3,268,817	3,392,356	3,413,804	3,530,181	3,195,697	3,344,081
Commercial	2,296,482	2,235,746	2,415,026	2,477,361	2,331,496	2,436,012
Industrial	926,726	989,726	1,012,129	1,018,325	956,473	998,860
Transportation	4,765,753	4,892,024	4,876,428	4,905,985	4,897,796	5,023,814
Waste	165,712	177,180	174,389	159,402	166,805	176,018
Metric Tons eCO2	**11,423,490**	**11,687,033**	**11,891,774**	**12,091,254**	**11,548,267**	**11,978,784**

This is the initial study of its kind for the County and Government. ***Because of the data assumptions and organizational boundaries used in this study, the results are expected to be low-end estimates***.

BAU projections for 2012 are 148 KMt eCO_2, an acceptable value that reflects only slight growth rate for County Operations and does not exceed the range of total emissions for the period examined.

Performance Targets

Maryland Climate Action Plan
Near and Long Term GHG Reduction Goals

- 10 % reduction by 2012
- 15 % reduction by 2015
- 25% - 50% reduction by 2020
- 90% reduction by 2050

Maryland has recently created a Climate Action Plan that includes targets for reductions. Recently, Baltimore County decided to follow the State's lead and set goals to reduce 2006 GHG emissions by 10% by 2012. Individual strategies for reductions in each sector will likely begin with the largest emitters, transportation and buildings, and are the focus of the newly formed Sustainability Network.

The primary purpose of these base year inventories is to provide information to the Community and the County Government on energy consumption and GHG emission patterns, since participation in a climate registry is currently not mandated, but may be in the near future. The newly formed Government's Sustainability Network will use this information to set goals for energy reductions, take steps to meet those goals, and provide an example of leadership in energy efficiency and sustainable action to the larger Community.

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Acronyms and Key Terms

BGE	Baltimore Gas and Electric
CACP	Clean Air Climate Protection Software Model
CH_4	Methane
CO_2	Carbon Dioxide
EIA	Energy Information Administration
EPA	United States Environmental Protection Agency
eCO_2	equivalent Carbon Dioxide
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
KMt	Thousand Metric Tons
MMt	Million Metric Tons
NEMS	National Energy Modeling System
N_2O	Nitrous Oxide
PFC	Perfluorocarbon
SIT	State Inventory Tool
URDL	Urban Rural Demarcation Line
VMT	Vehicle Miles Traveled
WRI	World Resource Institute
WBCSD	World Business Council for Sustainable Development

Tables and Figures

Acknowledgements

I would like express appreciation to many Baltimore County elected officials, staff members and environmental professionals for the support and assistance provided to this endeavor. In particular thanks go to: David Carroll, Director of the Office of Sustainability; Kathy Reiner Martin, Commission on Environmental Quality, chairperson; Melissa Stults, ICLEI; and Mary Staub, BGE.

Overview

Geography

Maryland is located in the Middle Atlantic Region of the United States. With an area of 9,770 square miles and 5.3 million people, it has the 19th largest population with the 42nd largest land area (US Census, 2000; DEPRM, 2008). Baltimore County, located in the north central part of the state, with an area of almost 600 square miles (3rd largest in Maryland) and a population of 754,292 (3rd largest in Maryland) is one of twenty-three counties in Maryland (US Census, 2000). Approximately 85% of the population lives inside the Urban-Rural Demarcation Line (URDL), on approximately 30% of the county's land (Anson, 2005). The county seat is in Towson and there are no incorporated municipalities.

Baltimore County contains over 2,000 miles of streams and 219 miles of Chesapeake Bay shoreline. It covers two geographical regions, the coastal plain and the piedmont (Maryland Geologic Survey, 2008). The coastal plain encompasses about 1/4 of the land area of the county and the topography is relatively flat. The remaining 3/4 of the county is located in the piedmont region which is an area of rolling topography that transitions between the coastal plain and the mountains of western Maryland.

Major Sectors

Baltimore County's major employment sectors include retail, financial services, health services, manufacturing, construction, education and public administration (US Census, 2000). The major industrial operations include a steel mill and steel products manufacturer, and industrial lubricant and sealant manufacturers. There are cement manufacturers, a paper company, and two electric power plants. These contribute, directly or indirectly, to greenhouse gas emissions through the combustion of fossil fuels and other industrial processes.

According to the 2000 US Census, there were almost 300,000 households in Baltimore County and 600,000 vehicles registered from County addresses with the State Motor Vehicle Administration. Farms are concentrated in the northern part of the county, forests cover about 1/3 of the land and there is one active landfill (A Citizen's Guide to Planning and Zoning in Baltimore County, 2006; State of our Forests, 2007; DEPRM Ten Year Solid Waste Management Plan, 2008). All are sources of greenhouse gas emissions through the combustion of fossil fuels, the use of fertilizers and the decomposition of organic matter.

Past Efforts

In the past, efforts to identify and to measure anthropogenic greenhouse gas emissions have focused on global and national levels. For more than a decade, the EPA has recognized the need for state-level action to decrease greenhouse gas emissions, has supported and encouraged states to compile their own emissions inventories, and developed the State Inventory Tool (SIT) to assist them. In 2001, Maryland conducted their first emissions audit for 1990, the base year for the Kyoto Protocol. Recently, projects such as the Global Change in Local Places (Kates, 1998) have recognized the tremendous variation in emissions that exists at the local level. In Maryland, for example, some counties have large urban areas, others are suburban, some are agricultural, and some support the mining industry or energy production. These inherent differences result in distinct GHG emissions patterns, which demonstrate the need for local entities to compile inventories and formulate action plans that address their unique energy consumption pattern. Some local municipalities (i.e., Annapolis) and counties (i.e., Montgomery County) in Maryland have recently conducted a GHG emissions audit.

Current Efforts

Currently, there is no firm federal commitment to reduce greenhouse gas emissions. However, under the guidance of Governor O'Malley, Maryland has taken steps in this direction (see box below). Baltimore County followed suit in April 2008 by establishing its own Sustainability Network to address the issues of energy efficiency and sustainable action within its own operations. The County willingly supported the research reported here, the first GHG inventory for Baltimore, as a means to identify its unique emissions footprint, reflecting the distinct set of activities that occur within its boundaries. Equipped with this information, it can now initiate steps for GHG reductions.

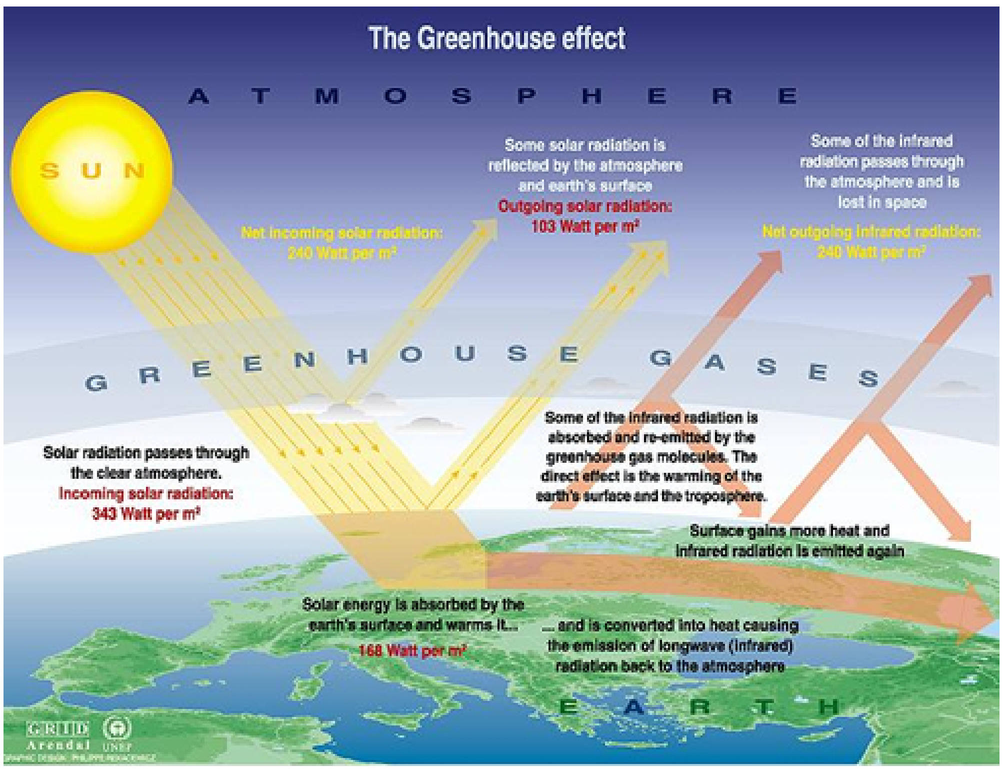
Maryland has adopted the following to address climate change :

- Healthy Air Act, 2006 , includes provision for Maryland to join the Region Greenhouse Gas Initiative, a ground breaking cap-and-trade program designed to reduce emission of CO_2 from power plants in the North-East and Mid-Atlantic states
- California Clean Cars program of more rigorous standards in vehicle model year 2011
- EmPOWER Maryland Program, 2007, designed to reduce per capita electricity use by Maryland consumers by 15% by 2015

Climate Change

Scientists have determined that changes in the amounts of greenhouse gases are responsible for an increasingly dominant role over the last century (Mann et al, 1998). Evidence exists that the Earth's surface temperature has risen 0.5°C since 1975 (Hansen et al., 1999) as a result of increased concentrations of GHGs, and the warming is likely to continue (Burns et al**.,** 2007). The positive forcing caused by the burning of fossil fuels and other human activities has brought about an accumulation of these gases to levels that exceed the ability of the Earth's ecosystems to absorb them as part of the natural cycle (Shindell,1998) (Figure 3).

Figure 3 Radiative energy balance between sun and earth



Source: Okanagan University College, Canada; University of Oxford, England; US EPA

Ninety-nine percent of the atmosphere is composed of nitrogen and oxygen and these exert almost no greenhouse effect because they are essentially transparent to solar and terrestrial radiation. Water is the most abundant and dominant greenhouse gas in the atmosphere and occurs naturally as clouds, fog, rain, snow and humidity (McMichael, 2003). While human activities do contribute some water vapor to the atmosphere, the amount is negligible compared to the amount that is cycled naturally everyday through the atmosphere. Instead warming of the atmosphere comes from gases that are less abundant.

The greenhouse gases that are of chief concern for climate change are:

1. Carbon Dioxide (CO_2), while naturally occurring, is the primary anthropogenic greenhouse gas, contributing “approximately 63% of the gaseous radiative forcing responsible for anthropogenic climate change” (Hoffman et al., 2006). Concentrations in the atmosphere increased from approximately 280 parts per million (ppm) since pre-Industrial times to 380 ppm in 2005 (Raupauch et al., 2007). The IPCC definitely states “the present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2” (IPCC, 2001). The predominant sources of anthropogenic CO_2 emissions are the combustion of fossil fuel and effects of land use changes on plant and soil carbon;

2. Methane (CH_4) concentration in the atmosphere of 1,774 ppb in 2005 is more than double its pre-Industrial value (IPCC, 2007). Its overall force as a greenhouse gas is second only to CO_2, contributing approximately 24% of the gaseous radiative forcing responsible for anthropogenic climate change. It is produced primarily through anaerobic decomposition of organic material in biological systems, enteric fermentation in animals, rice cultivation, coal mining, natural gas production and incomplete fossil fuel combustion (Bousquet et al., 2006);

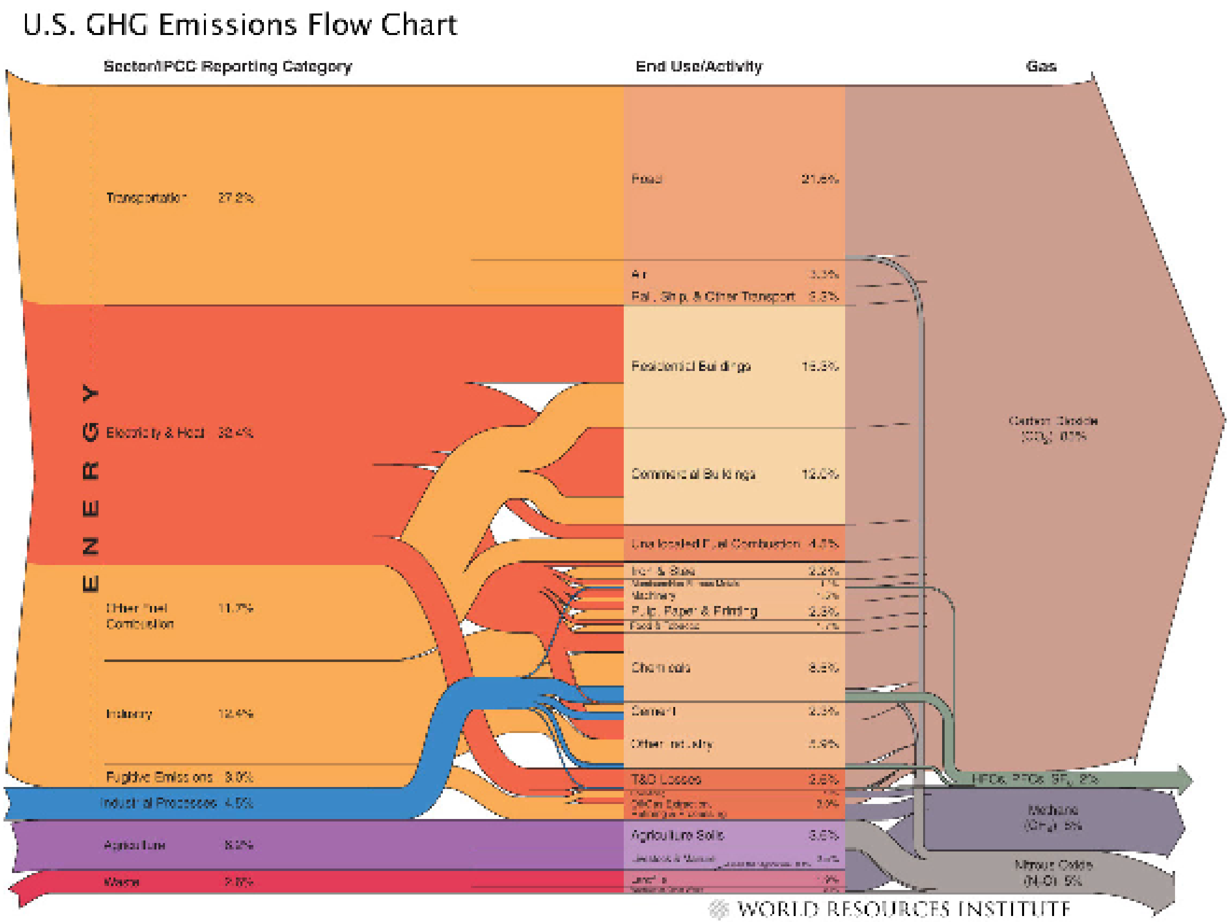
3. Nitrous Oxide (N_2O) The N_2O concentration in the atmosphere in 2005 was 319 ppb, about 18% higher than pre-Industrial values (IPCC, 2007), contributing approximately 6% of the gaseous radiative forcing responsible for anthropogenic climate change. Anthropogenic sources include agriculture soils, especially the production of nitrogen-fixing crops, use of fertilizers, fossil fuel combustion especially mobile combustion, wastewater treatment and waste combustion, and biomass burning (Fluckiger et al., 1999);

4. Hydrofluorocarbons (HFCs), **Perfluorocarbons** (PFCs), **Sulfur hexafluoride** (SF_6) are man-made chemicals that are powerful greenhouse gases emitted during manufacturing and industrial processes, such as HCFC manufacturing, aluminum smelting, semiconductor manufacturing and electric power transmission and distribution. Concentrations are relatively small but increasing rapidly (Olivier et al., 2000);

5. Ozone (O_3) exists in both the upper stratosphere, where it shields the Earth from harmful levels of ultraviolet radiation, and at lower concentrations in the troposphere, where it is the main component of smog. Tropospheric ozone provides the third largest increase in direct radiative forcing since the pre-Industrial era, behind CO_2 and CH_4. It is produced from chemical reactions that involve volatile organic compounds mixing with NO_x in the presence of sunlight. They are short-lived compounds and concentrated in certain areas (IPCC, AR4).

A number of additional gases act as GHGs, such as chlorofluorocarbons, carbon tetrachloride and methyl chloroform. For the purposes of this inventory the focus is on CO_2, CH_4 and N_2O because they comprise the majority (98%) of GHGs generated in U.S. (Figure 4). HFCs and PFCs are important GHGs with high Global Warming Potentials. Levels of these chemicals are expected to rise over the next decades (Maryland Climate Action Plan, 2008) and should be considered in subsequent inventories.

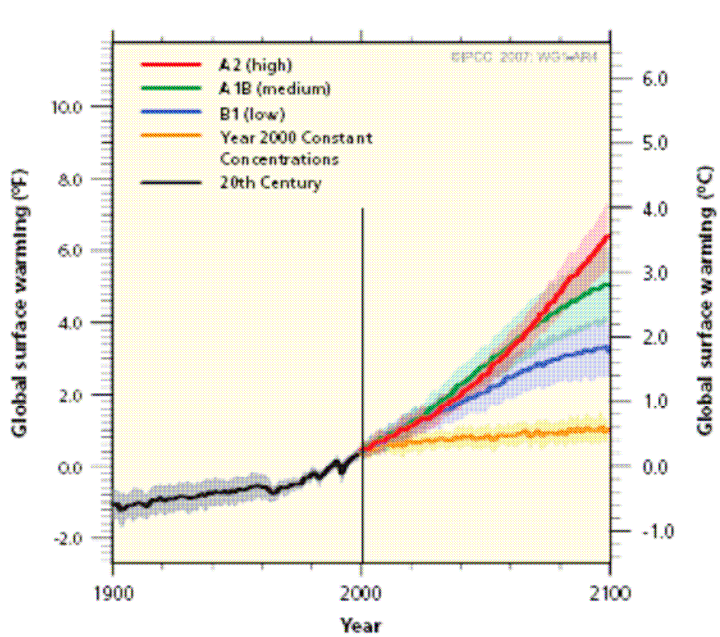
Figure 4 World Resources Institute US GHG Emissions by Sector Flow Chart



Scientific models have yet to determine the precise magnitude and long-term effects of greenhouse gases on climate. However most models suggest that climate change could have serious environmental impacts (Figure 5).

Baltimore County is susceptible to the effects of climate change, for example, by flooding coastal area, more severe storms, higher temperatures and drought conditions affecting agriculture, forests, reservoirs and coastal ecosystems (Maryland Climate Action Plan, 2008).

Figure 5 Estimates of Change in Surface Temperature from 20 year average, based on Changes in GHG Emissions



Methodology

There are several tools and protocols available for a GHG inventory, such as the EPA's State Inventory Tool extensively used by individual states in the U.S., and the World Resources Institute's GHG Protocol, a popular tool for businesses.

The software used in this study is *Clean Air and Climate Protection* by Torrie Smith Associates. It was designed for the International Council for Local Environmental Initiatives (ICLEI) and National Association of Clean Air Agencies (NACAA) to support local governments as they develop strategies to combat global warming and air pollution. It is intended to track emissions and reductions of greenhouse gases. This tool can create an emissions inventory for the community as a whole and for the government's internal operations, quantify the effect of existing and proposed emissions reduction measures, predict future emissions levels, set reduction targets, and track progress towards meeting those goals. The software contains emission factors that are used to calculate emissions based on simple fuel and energy use, and waste disposal data. It is recommended by the USEPA for use by local jurisdictions.

It should be noted that the inventory is an end-use accounting system, consumption based, and might not include all emissions that occur here. Energy data included in the inventory are based on fuels consumed here, not necessarily produced here. This way a jurisdiction can account for emissions resulting from its consumption patterns and consequently be in a better position to design effective tactics to alter or reduce these emissions.

Definition of Scope

A discussion of a GHG inventory should include what is meant by the scope of the inventory. The World Resources Institute (WRI) and World Business Council on Sustainable Development (WBCSD) collaborated to develop a widely accepted and standardized protocol for a voluntary GHG emissions inventory for institutions and they identify three potential 'scopes' for a GHG inventory. Scope 1 encompasses an organization's direct GHG emissions, from on-site production or other industrial activities. This includes what comes out of smokestacks and tailpipes (company owned vehicles). Scope 2 includes energy that is purchased from off-site, primarily electricity. Scope 3 encompasses a broad range of activities, from employee commute and business-related travel, to upstream emissions embedded in products, to downstream emissions associated with disposing of goods sold by the company. Where inventory reporting is mandatory, Scope 1 and 2 emissions are the minimum that must be reported, and Scope 3 emissions are optional.

It is clear that Company A's Scope 3 emissions are Company B's Scope 1 emissions, and full reporting of all scopes of all companies would include counting the same emissions several times. However, going through a Scope 3 analysis provides insight into the global implications of a company's activities. For example, a company can decide to locate an office in an area with easy access to a mass transit system, and lower their Scope 3 emissions. This part of an emissions inventory can be challenging work and a complete Scope 3 inventory can be 30 times Scope 1 and 2 but working through their supply chains, a business can control their energy reduction efforts beyond what they would accomplish focusing only on their own Scope 1 and 2 emissions.

The inventory of Baltimore County includes Scope 1 (Transportation), Scope 2 (energy imported to Residential, Commercial and Industrial sectors) and Scope 3 (waste disposal). It is considered a bottom-up inventory that looks to uncover consumption patterns of the community, such as driving patterns and electricity use. There are many other Scope 3 emissions that could be included, such as food procurement, that speak directly to consumption patterns and fit into the focus of the software model.

The Baltimore County inventory considers CO_2, CH_4 and N_2O emissions, and aggregates them into a value of metric tons of CO_2 equivalent, a commonly used unit that combines greenhouse gases of differing impact on the Earth's climate by weighting them by their warming potential (Table3).

Table 3 Global Warming Potentials, IPCC, Third Assessment Report, 2001

GHG	100 Year GWP
CO_2	1
CH_4	23
N_2O	296

The software is comprised of four modules, two support the development of an emissions inventory and action plan to reduce county-wide emissions, and two support the development of an emissions inventory and reduction plan for the county government's internal operations.

Government

Greenhouse gases from the County's General Operations were calculated in the Government Analysis Module. These calculations were based on energy used and waste produced in County Administrative, Police and Fire, Court and Public Works facilities (county libraries and public schools were not included). Additionally, this module tracks fuel and waste costs which are useful in developing and implementing an action plan for reduction of energy usage.

The Module is organized in seven sectors**:** Buildings, Vehicle Fleet, Employee Commute, Streetlights, Water/Sewage, Waste, and Other. It accounts for the emissions from facilities, operations, programs, and vehicles owned and operated by the county government. The exceptions are the county landfills, which are included in the Community Analysis to facilitate comparisons with reduction measures directed at the entire community.

The County Government inventory is a subset of the Community inventory. Care was taken not to double count emissions.

Buildings, **Streetlights, Waste Water** - For three sectors, Buildings, Streetlights and Waste Water, data on energy usage were supplied by Baltimore County Department of Public Works, Building and Equipment Services and BGE. Indicators for each sector such as the amount of office space in square feet in government buildings, the number of streetlights, and the volume of output of wastewater were included whenever, possible.

Vehicle Fleet - The information on VMTs from County fleet was supplied by the County's Vehicle Operations Manager and emissions were estimated using default fuel efficiencies for each vehicle type (see Appendix A for additional details on default values and emissions factors). Heavy equipment and lawn mowing equipment were not included.

Employee Commute - In the Employee Commute Sector emissions were estimated from the amount of energy used during travel to and from work by County Government employees based on a survey of Department of Environmental Protection and Resource Management (DEPRM) staff (82 replies out of 110 staff members. See Appendix B for data assumptions and survey results). Employee commute was included to capture Scope Three emissions for which County Operations are responsible, and to calculate the benefits of employee commute trip reductions measures. The sector has the same inputs as the Vehicle Fleet Sector, VMT.

Waste - The Waste Sector estimated emissions from waste shipped to the County Eastern Sanitary Landfill from County General Operations and the composition of the waste stream. Waste tonnage is not tracked for institutional customers therefore the estimation of waste tonnage was derived by taking the average of two methods for waste generation in office buildings described by New York Department of Sanitation (See Appendix B for calculations used for the estimations of total tonnage of solid waste collected at County Buildings). The Methane Commitment Method is used in the CACP Model to calculate all future emissions (methane can be emitted from a landfill for 20 – 40 years depending on conditions) from solid waste, which it applies to the active year (see appendix A for explanation of Methane Commitment Method). Data required are the amount of waste, the method of disposal, and the percent of methane recovered, all provided by the County Public Works Department, Ten Year Solid Waste Management Plan.

Other - The Other Sector is used to enter the absolute amount of greenhouse gases (HFCs, PFCs) emitted from government activities that are not included in any specific sector. None were included in this study.

Organizational Boundary - An important first step in an organization's inventory is to clearly identify its organizational boundary. Baltimore County Government GHG emissions inventory was conducted on facilities and operations that were under the jurisdiction of General Government Operations in 2002 through 2006**.** It included 104 Administrative offices, Police and Fire stations, Public Works facilities, approximately 1500 County owned vehicles, Streetlights and Traffic Signals, Waste Water pumping stations, Solid Waste and Employee Commute. Data were gathered from these sources for FY2002 – 2006.

As this was the initial inventory for the County, challenges arose in data collection for all sectors. County employees took pains to research the databases for the requested material, but data gaps exist and assumptions were made that were based on the information that was supplied (see appendix B for details on data assumptions). The inventory does not include emissions from County libraries, Public School buildings or buses, which are under different governance (Board of Education and Board of Library Trustees). ***The results of this study, therefore, are expected to be low-end estimates.***

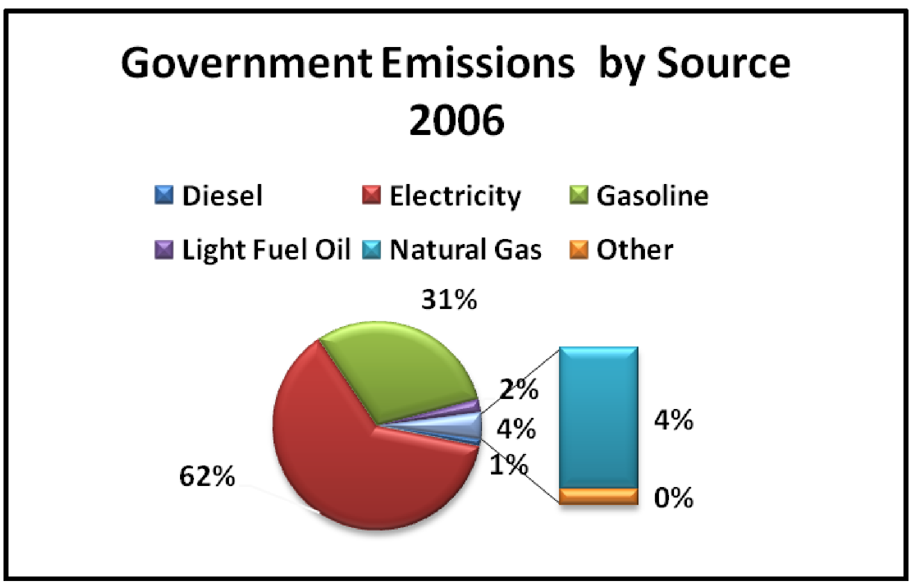
Results

Government

In 2006 Baltimore County General Government Operations generated 142.7 KMt eCO_2. The Buildings Sector produced the most emissions, followed by Waster Water Pumping, Employee Commute, County Vehicles, Streetlights, and Solid Waste (Figure 6 and Table 4). During the 5 year period from 2002 to 2006, the Government GHG emission were dominated by Buildings Sector, which remained stable, and Waste Water, which decreased as the volume of water decreased. Vehicle Fleet, Employee Commute, and Waste Sectors remained stable throughout the period.

Under business as usual conditions, GHG emissions from Government operations are estimated to approach 148 KMt eCO_2 in 2012, an increase of 3.8% over base year emissions. Projecting future emissions levels presented challenges because emissions demonstrate a downward trend since 2003, and government energy use is generally expected to remain stable or grow at a slower rate than the community. 148 KMt eCO_2 is acceptable since it reflects slight growth for County Operations and does not exceed the range of total emissions for the period examined. Reductions of 10% of base year value, or 14,300 tons, bring total emissions to 128.4 KMt eCO_2.

Figure 6 County Government GHG Emissions by Source, 2006



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Metric Tons eCO2	**149,802**	**144,729**	**148,913**	**145,327**	**142,701**	**148,258**

Buildings – In the base year (2006) Government Buildings generated over 39 KMt eCO_2, the highest emissions of all the sectors. There are over 2.7 million square feet, and almost \$6 million spent on energy, which produced the following emissions: 54.5 million kWh electricity generated 31.2 KMt eCO_2, 934k therms of natural gas generated 5.1KMt eCO_2, and 273,000 gallons of heating oil generated 2.9 KMt.

Some buildings appear to be more energy efficient based on cost of electricity per ft^2 (ranging from \$0.77/ft^2 to over \$4.00/ft^2) and may provide opportunities for investigating building efficiency (Table 5).

Table 5 Sample of Variation of Electricity \$/Ft^2 in Govt. Buildings, 2007

Station	kWh	Costs	Ft²	\$/Ft²
Chase FS-#54	124,900	\$11,129.50	9,105	\$ 1.22
Cockeysville Prec. #7	241,734	\$21,576.37	11,608	\$ 1.86
Crash Team Office	71,306	\$6,381.38	1,792	\$ 3.56
Detention Center	10,486,360	\$934,790.50	490,740	\$ 1.90
Dundalk FS-#6	156,300	\$13,922.70	6,803	\$ 2.05
Edgemere FS-#9	181,400	\$16,654.40	5,506	\$ 3.02
Essex Police Prec. #11	335,262	\$30,064.56	15,020	\$ 2.00
Essex FS-#7	109,900	\$9,797.50	2,964	\$ 3.31
Franklin Fire Station	75,000	\$6,713.10	9000	\$ 0.75
Franklin Police Station	582,100	\$52,185.70	24,370	\$ 2.14

In order to check accuracy of the data it is necessary to have multiple data sources for comparison. The sole opportunity during the inventory process occurred with data on energy use in buildings. KWhs used in County Government Buildings were obtained from Baltimore County Bureau of Building and Equipment Services and BGE. The data compare favorably, with less than 10% variation, with one exception (Table 6). Differences may arise from calendar year (BGE) and fiscal year (County) based data.

Table 6 Sample of kWh data used in Baltimore County Buildings, from BGE and Baltimore County Bureau of Building Services, 2007

Building Name	BGE kWh	BC kWh	%variation from BC data
Ateaze Senior Center	340,100	326,100	**4.12**
Banneker Community Center	142,600	146,700	**-2.88**
Brady Ave. Utilities Bldg.	176,600	165,800	**6.12**
Brooklandville FS-#14	112,740	113,280	**-0.48**
Bykota Senior Center	574,400	563,500	**1.90**
Catonsville Senior Center	395,600	417,865	**-5.63**
Cockeysville Police Prec. #7	242,637	241,734	**0.37**
Cockeysville Senior Center	149,400	150,700	**-0.87**
County Office Building	1,590,400	1,677,300	**-5.46**
Crash Team Office	59,028	71,306	**-20.80**

Solid Waste - Solid waste, estimated at 2,400 tons, generated 0.57 KMt eCO_2. Emissions from the Solid Waste Sector were stable from 2002–2006. Waste amounts for commercial customers are not tracked by haulers and estimates were made of the amounts generated by the County Government based on studies conducted by the New York Department of Sanitation (see appendix B). An additional 300 tons of paper and other materials were recycled.

County Vehicles - The County vehicle fleet generated 20,162 KMt eCO_2. This sector includes 1500 vehicles of various types from compact gas vehicles to 4-ton diesel trucks, and accumulates 23 million miles per year, with police vehicles (Ford Crown Victoria) accumulating over 9 million. No data on heavy equipment were included in this sector.

Employee Commute - Emissions from this sector were 24,820 KMt eCO_2 and are based on a survey of driving patterns of DEPRM staff (82 respondents out of 110) and scaled to all 8000 county employees commuting 47 million miles. Results of the survey showed that 87% drive alone, 6% bike/walk, 5% carpool and 2% use mass transit. Actual miles and emissions may be higher for this sector because the sample pool is small (about 1% of County staff) and DEPRM employees may choose to live close to work or use alternate transport at a higher rate, but the survey provides a good estimate for County Employee Commute (see Appendix B for further discussion of data assumptions).

Streetlights/Traffic Signals – This sector generated 18,854 KMt eCO_2 for the County Government in the base year. Half of the decrease in County Operations GHG emissions from 2005 to 2006 can be attributed to the streetlight/traffic signal sector (4.7% decrease). The County has taken energy reduction measures in the lighting sector that may have influenced these results. The County is responsible for approximately 41,000 streetlights (30 million kWh and $2.3 million annually) and 235 traffic signals (2.3 million kWh and $250,000). In 2002, the County began a two phase program of switching to energy efficient technology in its 235 traffic signals traffic. The first phase included the red lights and the pedestrian hand signals. The yellow and green traffic signals are currently in the process of being converted over to more energy efficient technology.

Waste Water - Emissions from the Waste Water Sector are 38,665 KMt eCO_2 and are based on number of gallons pumped annually. The number of gallons rose during 2002 to 2004 (39 billion gallons to 48 billion gallons), then declined and leveled off in 2006 (43 billion gallons). The GHG emission followed this pattern closely. There are two separate systems for handling waste water and storm water, but during heavy rainfall events, storm water flows into the sewer system and is pumped to the treatment plant. Rainfall amounts were above normal (41.9 in.) in 2003 – 2005 (62in., 45 in., 49 in.) that could have contributed to the rise in number of gallons pumped. It is challenging to say that the increase in rainfall contributed to increase volume pumped because the increase could have come from many small events and not caused an overflow. A closer investigation into each rain event is necessary to know if overflow occurred.

Other - There were no items included in the Other Sector because the lack of available data. Other sources of GHG that should be included in subsequent inventories are refrigerants for County buildings' cooling systems, fertilizers applied to lawns and parks, and County owned forests. It is likely that these omissions will affect the County's Government's GHG emissions, but without actual data it is challenging to estimate total impact.

Total County Government GHG emissions varied by less than 5% during the period of 2002–2006, and decreased slightly during that last 3 years. Increases in the number of County employees (4.3%) and total yearly budget (25%) did not affect the energy use or GHG emissions. Emissions reductions were seen in Streetlight/ Traffic Signal Sector because of energy efficiency measures the County put in place, and in the Waste Water Sector mentioned above. Other opportunities exist in the Building and Employee Commute Sectors for energy and GHG emissions reductions. The County Sustainability Network now has the baseline information they need to begin planning strategies that will assist Government Operations meet their target for GHG reductions in 2012.

Community

It is estimated that Baltimore County generated 11.5 MMt of eCO_2 in 2006. Transportation was the largest contributor followed by the Residential, Commercial, Industrial and Waste Sectors. Electricity is the largest source followed by gasoline and natural gas (Figure 7 and Table 7).

Figure 7 Community GHG Emissions by Source 2006

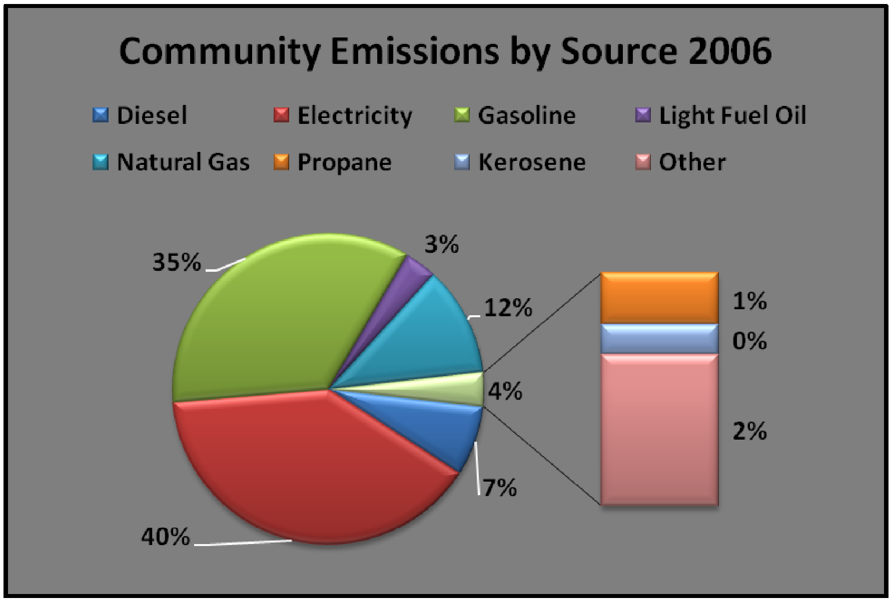

Table 7 Community GHG Emissions by Sector, 2002 – 2006, 2012

Year	*2002*	*2003*	*2004*	*2005*	*2006*	*Projections* *2012*
Residential	3,268,817	3,392,356	3,413,804	3,530,181	3,195,697	3,344,081
Commercial	2,296,482	2,235,746	2,415,026	2,477,361	2,331,496	2,436,012
Industrial	926,726	989,726	1,012,129	1,018,325	956,473	998,860
Transportation	4,765,753	4,892,024	4,876,428	4,905,985	4,897,796	5,023,814
Waste	165,712	177,180	174,389	159,402	166,805	176,018
Metric Tons eCO_2	**11,423,490**	**11,687,033**	**11,891,774**	**12,091,254**	**11,548,267**	**11,978,784**

Comparisons with other Governments are made on a sector-to-sector basis, since gross amount comparisons are less meaningful because of organizational boundaries. A few points are clear, however. First, electricity is the largest source of emissions contributor to GHG emissions (Buildings, Streetlights, Waste Water) in all three inventories. Second, energy consumed by Waste Water can be as high as that used in Buildings. Finally, indirect emissions generated by Staff Commute, while challenging to quantify, can be a significant part of a jurisdiction's inventory (Table 8).

Table 8 Comparisons of GHGs with other Governments by Sector

	% Emissions		
Government	Baltimore*	Annapolis	Durham
Buildings	27.8 (33.7)	27.5	47.0
Vehicle Fleet	14.1 (17.1)	31.8	16.0
Staff Commute	17.4 (NA)	NA	NA
Streetlights	13.2 (16.0)	10.3	8.00
Water/Sewage	27.1 (32.8)	29.6	29.0
Waste	0.4 (0.50)	0.7	<1.0
% Emissions	100 (100)	99.9	100
*** with(with-out) Staff Commute**			

Scenarios for Reductions

Maryland has recently created a Climate Action Plan that includes a State-wide GHG emissions inventory, targets for reductions and an outline for actions to achieve the targets. If Baltimore County decides to follow the State's lead, then they will set goals to reduce 2006 GHG emissions by 10% by 2012.

Individual strategies for reductions in each sector, beginning with the largest emitters, transportation and buildings, will require detailed analyses for passing a two-fold test that 1) reduces CO_2 and meets the 10% reduction goals, and 2) offers the highest monetary return on investment or shortest payback period. Transformational changes that handle options for positive payback should also be considered, not only 'low hanging fruit'. However, such a comprehensive analysis exceeds the scope of this project and is the mission assigned to the Sustainability Network.

It is within the scope of this study to examine a small number of scenarios for emissions reductions from the largest sources

The major emitters for the County Government Operations were Buildings, Waste Water Pumping and Employee Commute. As in the Commercial Sector of the Community Inventory, emissions from GHGs in County Buildings could be reduced by modifying employees' behavior. A 5% reduction of energy used in the County Buildings would be equivalent to a 2,000 tons reduction in emissions or 14% of Government goal of 14,300 tons. Some of these changes include (but are not limited to) powering down computers when not in use, shutting equipment off, using natural and task lighting. Staff education, input, and participation are integral to the success of reduction programs.

Reductions from Waste Water Sector could be realized by Community participation in source reduction. The American Water Works Associations reports that installing efficient water fixtures and repairing leaks can reduce daily per capita water use by 35%. If energy used by Waste Water Pumping were reduced 10% by lowering the amount of waste water entering the system, GHG emissions would be reduced by 3,866 tons or 27% of the target for reduction. Community residents and/or County Government would incur material and installation costs from this reduction, and alternative sources for funding, such as the Maryland Energy Administration, could be considered. The Waste Water Sector is a major emitter and some measures for emissions reductions are likely to arise from this sector to meet the reduction goals.

To reduce fuel costs and GHG emissions from Vehicle Fleet, the Vehicle Operations and Management Department is investigating the cost-benefit of switching to hybrid vehicles, and has compact hybrid vehicles (i.e. Toyota Prius) in its fleet. Currently, the County participates in a State purchasing contract and can purchase compact gas vehicles for $11,000 less than a hybrid (per County Vehicles Operations and Maintenance Manager). Even with gasoline prices $4.00/gal, it would not be cost effective to convert from gas to hybrid vehicles (Table 9). As hybrid technology becomes more affordable and extends successfully to full size vehicles, converting the fleet to hybrid vehicles will significantly lower emissions generated by this sector.

Table 9 Payback on Hybrid Honda Civic

	# Gal per 10k miles	Gas Prices per gal $ 3.50	$ 4.00	$ 4.50	$ 5.00
Ford Focus(28.5mpg)	350.88	$ 1,228.07	$1,403.51	$1,578.95	$ 1,754.39
Honda Civic(42.5mpg)	235.29	$ 823.53	$ 941.18	$1,058.82	$ 1,176.47
$ saved on gas annually		$ 404.54	$ 462.33	$ 520.12	$ 577.92
# Years to payback $11K		27.19	23.79	21.14	19.03

Finally, the Employee Commute Sector contributes the third largest amount of emission from Government Operations. The results of the Employee Survey indicated that over 30% of staff were in interested in a carpooling program. Recently, County Government established a carpooling program that offers additional benefits to participants, such as paid parking and guaranteed ride home. If 10% of County employees participate in this program, reductions from this sector would equal to almost 2,500 tons or 17% of the County total reduction goal.

Reductions in Community and Government Operations can be accomplished through a coordinated effort of residents, employees and elected officials, to set goals, plan a path to successful implementation, and making the necessary changes. Resources are available from organizations such as EPA and ICLEI, that outline steps that can be taken and success stories from other communities. The political will, vital to success, now exists in Baltimore County and is embodied in the Sustainability Network.

Suggestions for Improving Subsequent Inventories

In the next County Government inventory the following should be considered:

1) Track energy used in buildings (kWh, therms, gallons);

2) Include refrigerants used in County buildings;

3) Include fertilizers used on lawns and in parks;

4) Include emissions from heavy equipment and lawn mowing equipment;

5) Survey a larger sample of County employees to determine commuting patterns.

References

Alley, R., Marotzke, J., Nordhaus, W. D., Overpeck, J. T., Peteet, D. M., Pielke Jr., R. A., Pier-Rehumbert, R. T., Rhines, P. B., Stocker, T. F., Talley, L. D., and Wallace, J. M. 2003. Abrupt Climate Change. Science 299: 2005 – 2010.

American Water Works Association. Water Use Statistics. Retrieved on Nov. 9, 2008, from http://www.drinktap.org/consumerdnn/Default.aspx?tabid=85

Anson, M. Mar 23, 2000. Bringing Up Smart Growth. The Sun. Baltimore Maryland.

Baltimore County, Department of Public Works, Ten Year Solid Waste Management Plan. Retrieved on Oct 10, 2008, from http://www.baltimorecountymd.gov/Agencies/publicworks/recycling/tenyearplan.html.

Baltimore County Office of Planning. January 2006. A Citizen's Guide to Planning and Zoning in Baltimore County. Retrieved Nov. 3, 2008, from http://resources.baltimorecountymd.gov/Documents/Planning/Citizens%20Guide%20to%20Zoning/1_Intro%20and%20Rural.pdf.

Bousquet, P., Ciais, P., Miller, J. B., Dlugokenck, E. J., Hauglustaine, D. A., Prigent, C., Van der Werf, G. 2006. Contribution of anthropogenic and natural sources to atmospheric methane variability. Nature 443: 439 – 443.

Brodsky, S., Stark, A. Best Practice to Improve Energy Performance in Commercial Buildings. US EPA. Retrieved Nov. 4, 2008, from http://www.energystar.gov/index.cfm?c=comm_real_estate.bus_comm_realestate_workshop#s2.

Brown, S., Cannell, M., Heuveldop, J., Kauph, P., Sathaye, J., Singh, N., Weyers, S., Dixon, R., Grainger, A., Leeman, R., Moura-Costa, P., Milsson, S., Pinard, M., Schopfhauser, W., Sedio, R., Trexler, M. 1996. Chapter III F. Establishment and Management of forests for mitigation of Greenhouse Gas Emissions. In Working Group II, IPCC, 1995 Assessment for the Framework Convention on Climate Change.

Burns, D. A., Klaus, J., McHale, M. 2007. Recent climate trends and implications for water resources in the Catskill Mountain region, New York, USA. Journal of Hydrology 336: 155 – 170.

Burtraw, D., Toman, M. May 2003. Estimating the Ancillary Benefits of Greenhouse Gas Mitigation Policies in the US. Journal of Environmental Economics and Management 45: 650 – 673.

CACP User Guide. June 2003. Clean Air and Climate Protection User Guide. State and Territory Air Pollution Program Administrators, Association of Local Air Pollution Control Officials.

Choi, Yu-Jin. 2004. A Study of Ground Level Ozone Over the Baltimore/Washington Ozone Non-Attainment Area. Digital Repository at the University of Maryland. Retrieved on Oct. 20, 2008, from http://hdl.handle.net/1903/1789.

Cox, P. M., Betts, R. A., Jones, C. D., Spall, S. A.,Totterdell, I. 2000. Acceleration of Global Warming Due to Carbon-Cycle Feedbacks in a Coupled Climate Model. Nature 408: 184 – 187.

DEPRM. Baltimore County Department of Environment al Protection and Resource Management 1997 Land Use. Retrieved on Nov. 3, 2008, from http://www.baltimorecountymd.gov/Agencies/economicdev/gateway/demographics/index.html.

DEPRM. December 2007. State of our Forests Report. Retrieved Nov. 3, 2008, from http://resources.baltimorecountymd.gov/Documents/Environment/Workgoup/programimplementation/forestassessment/07stateourforests.pdf.

Desjardins, R., Sivakumar, M., de Kimpe, C. 2006. The contribution of agriculture to the state of climate. Agricultural and Forest Meteorology 142: 314 – 324.

EPA. Carbon Sequestration in Agriculture and Forestry. Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural & Forestry Practices. Retrieved Nov.1, 2008. from http://www.epa.gov/sequestration/rates.html.

Farris, B. Oct. 6, 2008. Gov. O'Malley, Maryland receive National Recognition for Energy Efficiency Advances. US Federal News.

Fasullo, J., Trenberth, K. 2008. The annual cycle of the Energy Budget. Part I: Global mean and land–ocean exchanges. Journal of Climate 21: 2297 –2313.

Fasullo, J., Trenberth, K. 2008. The Annual Cycle of the Energy Budget. Part II: Meridional Structures and Poleward Transports. Journal of Climate 21: 2314 – 2326.

Fluckiger, J., Dallenbach, A., Blunier,T., Stauffer, B., Stocker, T., Raynaud, D., Barnola, J. 1999. Variations in Atmospheric N_2O Concentration During Abrupt Climatic Changes. Science 285: 227 – 230.

Ford, A., Fahrig L. 2008. Movement patterns of eastern chipmunks (Tamias striatus) near roads. Journal of Mammalogy 89: 895 – 903.

Green, A., July 2004, Federal auditors scrutinize Isabel claims Inspector general probes insurance disputes. The Sun. Baltimore, Maryland.

Hansen, J., R. Ruedy, J. Glascoe, and M. Sato 1999. GIS analysis of surface temperature change. Journal of Geophysical Research 30: 997 – 1,022.

Hansen, J., Sato, M., Ruedy, R., Lacis, A., Oinas, V. 2000. Global warming in the twenty-first century: An alternative scenario. PNAS 97: 9875 – 9880.

Hansen, J., Sato, M., Ruedy, R., Lo, K., Lea, D., Medina-Elizade, M. 2006. Global temperature change. PNAS 103: 14288 – 14293.

Historic Gasoline Prices. Retrieved Oct.10, 2008, from http://tonto.eia.doe.gov/dnav/pet/hist/mg_tt_usw.html

Hoffman, D., Butler, J., Dlugokencky, E., Elkins, J., Masarie, K., Montska, S., Tan, P. 2006. The role of carbon dioxide in climate forcing from 1979 to 2004: Iintroduction of the Annual Greenhouse Gas Index. Tellus B 58: 614 – 619.

IPCC. 2007. Intergovernmental Panel on Climate Change, Assessment Report 4. Retrieved on Oct. 21, 2008, from http://www.ipcc.ch/ipccreports/ar4-syr.html.

Karl, T., Trenberth, K. 2003. Modern Global Climate Change. Science 302: 1719 – 1723.

Kates, R., Mayfield, M., Torrie, R. D., Witcher, B. 1998. Methods for Estimating Greenhouse Gases from Local Places. Local Environment 3: 279 –298.

Kay, L. September 14, 2008. Living at $4.00 a gallon. The Sun. Baltimore, Maryland.

Khandekar, M., Murty, T., Chittibabu, P. 2005. The Global Warming Debate: A Review of the State of Science. Pure and Applied Geophysics 162: 1557 – 1586.

Madden, R., Ramanathan, V. 1980. Detecting Climate Change due to Increasing Carbon Dioxide. Science 209: 763 – 768.

Mann, M., Bradley, R., Hughes, M. 1998. Global-scale temperature patterns and climate forcing over the past six centuries. Nature 392: 779 – 787.

Maryland Greenhouse Gas Emissions Inventory 1990. 2001. Maryland Department of the Environment, Air and Radiation Management Administration. Retreived Nov. 3, 2008. http://www.mde.state.md.us/assets/document/Air/1990%20Greenhouse%20Gas%20Inventory.pdf.

Maryland Climate Action Plan. August, 2008. Maryland Commission on Climate Change Climate Action Plan. Retrieved on Oct.20, 2008, from http://www.mde.state.md.us/Air/climatechange/index.asp.

Maryland Geologic Survey. 2008. A Brief Description of the Geology of Maryland. Retrieved Nov. 3, 2008, from
http://www.mgs.md.gov/esic/brochures/mdgeology.html.

McMichael, A. J., Haines, A., Sloof, R., Kovats, S. 2003. Climate Change and Human Health. World Health Organization.

National Oceanic and Atmospheric Administration. National Climatic Data Center. Retrieved on Oct. 28, 2008.
http://lwf.ncdc.noaa.gov/oa/climate/globalwarming.html.

Novaco, R., Stokols, D., Milanesi, L. 1990. Objective and subjective dimensions of travel impedance as determinants of commuting stress. American Journal of Community Psychology 18: 23 – 27.

Olivier, J.G., Bakker, J. 2000. Historical global emission trends of the Kyoto gases HFCs, PFCs and SF_6. Proceedings of Conference on SF_6 and the Environment: Emission Reduction Strategies. San Diego, CA.

Paeth, H., Feichter, J. Jan 2006. Greenhouse-gas versus aerosol forcing and African climate response. Climate Dynamics 26: 35 – 54.

Pollan, M. 2006. The Omnivore's Dilemma: A Natural History of Four Meals. New York Penguin Press.

Raupach, M., Marland, G., Ciais, P., Le Quere´, C., Canadell, J., Klepper, G. 2007.Global and regional drivers of accelerating CO_2 emissions.
PNAS 104: 10288 – 10293.

Rial, J., Pielke, R., Beniston, M., Claussen, M., Canadell, J., Cox, P., Held, H., DeNoblet-Ducoudr, N., Prinn, R., Reynolds, J., Salas, J. 2004. Nonlinearities, Feedbacks and Critical Thresholds Within the Earth's Climate System.
Climate Change 65: 11 – 38.

Ramaswami, A., Hillman, T., Janson, B., Reiner, M., Thomas, G. 2008. A Demand-Centered, Hybrid Life-Cycle Methodology for City-Scale Greenhouse Gas Inventories. Environmental Science Technologies 42: 6455 –6461.

Roedenbeck, I., Voser, P. 2008. Effects of roads on spatial distribution, abundance and mortality of brown hare (Lepus europaeus) in Switzerland. European Journal of Wildlife Research 54: 425 – 437.

Roylance, F. August 27, 2008. State Climate Panel urges Action:Commission proposes 90 Percent Emissions Cut By 2050, Plans for Rising Water. The Sun. Baltimore, Maryland.

Shindell, D., Rind, D., Lonergan, P. 1998. Increased polar stratospheric ozones losses and delayed eventual recovery owing to increasing greenhouse-gas concentrations. Nature 392: 589 – 592.

STAPPA. State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials. Reducing Greenhouse Gases and Air Pollution: A Menu of Harmonized Options.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., de Haan, C. 2006. Livestock's Long Shadow: Environmental Issues and Options. Rome: Food and Agriculture Organization of the United Nations.

Saltelli, A., Tarantola, S., Chan, K. 1999. A quantitive model-independent method for global sensitivity analysis of model output. Technometrics 41: 39 – 56.

Saltelli, A., Chan, K., Scott, E.M. 2000. Sensitivity Analysis. John Wiley and Sons Publishers, Chichester, United Kingdom.

Tett, S., Betts, R., Crowley, T., Gregory, J., Johns, T., Jones, A., Osborn, T., Ostrom, E., Roberts, D., Woodage, M. 2006. The impact of natural and anthropogenic forcings on climate and hydrology since 1550. Climate Dynamics 28: 3 – 34.

Torrie, R.D. January 1993. Cities and CO_2: Research Results and Policy Implications from the Urban CO_2 Reduction Project. Prepared for Municipal Leader's Summit on Climate Change and the Urban Environment, United Nations, New York, (Toronto, International Council for Local Environmental Initiatives).

Ulbrich, U., Christoph, M. 1999. A shift of the NAO and increasing storm track activity over Europe due to anthropogenic greenhouse gas forcing.Climate Dynamics 15: 551 – 559.

Ullman, D. Sept. 30, 2008. Carbon dioxide allowances auction nets $16M for Maryland. The Daily Record

U.S. Census. United States Census 2000 PHC-T-2. Ranking Tables for States: 1990 and 2000 Table 1. States Ranked by Population: 2000.

US EPA. 1992. USEPA States Workbook, Methodologies for Estimating Greenhouse Gas Emission, 1992.

Vecchi, G., Soden, B. 2007. Global Warming and the Weakening of the Tropical Circulation. Journal of Climate 20: 4316 – 4340.

Appendix A

Emission Factors

A) Electricity - The emissions factors are the key to the software's calculations. They are the coefficients used to convert energy units (e.g., kWh) from a quantity of fuel used (e.g., kilograms of coal) to emissions of greenhouse gases. Although there are no emissions associated with electricity at the point of use, there are emissions of CO_2 and other GHGs at the fossil fuel power plant that generates the electricity. The software uses emissions factors to account for upstream emissions created by these plants (CACP User Guide). Making the connection between electricity consumption and emissions generation is an integral part of an end-user based accounting system.

The amount of CO_2 emitted during combustion is derived from three factors: the amount of fuel consumed, the fraction of the fuel that is oxidized, and the carbon content of the fuel (USEPA, 1992). The first is the activity data supplied by the model user, the second two are embedded as software default co-efficients based on fuel types and technologies' efficiencies.

The CACP tool employs emission factors for calculating GHGs from an assortment of processes across the Residential, Commercial, Industrial, Transportation and electric sectors. Major references include EIA energy projections, EPA emission inventories, life-cycle emissions models and emissions factor databases. CH_4 and N_2O emissions factors are obtained from the Intergovernmental Panel on Climate Change (IPCC, 1996). CO_2 emissions factors are provided for the NERC (National Electricity Reliability Council) regions. However, the local supplier, PJM Interconnection, provides CO_2 emission factors that closely reflect the fuel mix used for electricity supplied to Baltimore County and these values were used for calculating emissions from electricity, in conjunction with default values for CH_4 and N_2O. PJM values are not available for all years included in the inventory. For 2002 – 2005, the PJM 2005 value for CO_2 was used along with default factors for the remaining GHGs. For 2006 and 2012, the PJM 2006 value for CO_2 was used along with the default factors for the other GHGs.

Default values for determining criteria air pollutants levels are also provided but were not considered in this study.

B) Transportation- The Transportation sector has three key differences from other sectors. First, as the emissions of criteria air pollutants depend on the type of technology used, data are needed on vehicle types as well as fuel usage. Second, the energy usage information can be entered as actual fuel use or it can be estimated based on the total number of vehicle miles traveled (VMT). Finally, if the total fuel usage by vehicle type is not known, then default values in the software can be used to help derive these numbers.

The software requires information on VMT in the community to which it applies factors based on fuel and vehicle type, and fuel efficiency for each vehicle type (these are embedded in software as default values).

The quantification of emissions for the Transportation sector is based on a simple equation for describing the impact of a particular strategy. The following equation separates the VMT component (number of trips, length of trips, etc.) from the vehicle fuel efficiency (miles per gallon) and fuel components (emissions/unit of fuel). For both greenhouse gases and air pollutants:

$$Emissions = VMT \times Emissions\ per\ VMT \qquad (1)$$

The two terms in the above equation, VMT and Emissions per VMT, break down further. First, the VMT term:

$$VMT = \left(\frac{person-trips}{persons\ per\ vehicle}\right) \times trip\ length \qquad (2)$$

The term, Person-Trips/Persons per Vehicle, represents vehicle-trips. The difference between the number of individual person-trips and the number of vehicle trips depends on the number of person in the vehicle. The vehicle occupancy factor (persons per vehicle) is important and is the main reason that carpooling and public transit are effective methods of reducing emissions of passenger mile of travel.

The second term, Emissions/VMT, breaks down into factors that describe the fuel efficiency of the vehicle and the emission intensity of the fuel being used.

$$Emissions/_{VMT} = fuel\ efficiency \times emission\ per\ fuel\ unit \qquad (3)$$

Combining these five factors leads to the equation for Transportation emissions:

$$CO_2Emission = \left(^A/_B\right) \times C \times D \times E \qquad (4)$$

Where:

A = Number of person-trips made using the vehicle type
B = Number of people per vehicle
C = Trip length
D = Fuel consumption

E = Emission per unit of fuel (the fuel type factor)

Each one of these factors is determined by another number of technological and behavioral factors, and is not independent. In the case of cars, for example, fuel consumption per vehicle is higher for short trips (cold start) so that when 'C' for cars goes down, 'D' goes up.

Highway vehicles will be categorized into the following seven vehicle types as described in EPA methodology (USEPA, 1992):

LDGV - light-duty gasoline vehicles; passenger cars GVW less than 8500lbs;
LDGT - light-duty gasoline trucks; vehicles with GVW less than 8500lbs;
HDGV - heavy-duty gasoline vehicle; vehicles with GVW exceeding 8500lbs;
LDDV - light-duty diesel vehicles; cars with GVW less than 8500 lbs;
LDDT - light-duty diesel trucks; trucks and vans as described for LDGT;
HDDT - heavy-duty diesel trucks; as described for HDGV;
MCYC - motorcycles.

These are similar to vehicle types described in the Maryland inventory, which estimated VMTs using data from the Maryland State Highway Administration. The data were based on Highway Performance Monitoring System (HPMS), a national network used to determine approximate VMT estimates. Data for the Baltimore County VMTs were obtained from Maryland State Highway Administration.

C) Waste Greenhouse gas emission from waste and waste related measures depend on the type of waste and on the disposal method. The software considers five waste types (paper, food, plant, wood/textile, and other) and six management practices (open dump, open burning, managed landfill, controlled incineration, compost, and uncollected). Default percentages for waste types are included, and applied to user activity (tons of solid waste). For each waste and disposal practices combination, there is a set of emission factors that specify KMt of equivalent CO_2 emissions per ton of waste :

Factor	Description	Name
A	**eCO_2 emissions of methane per Ton of waste**	**Methane Factor**
B	**eCO_2 sequestered at disposal Site, in mTon per ton waste**	**Site Seq**

Emissions at the disposal site are calculated using the following equation:

$$eCO_2 = W_t[(1-r)A + B] \quad (5)$$

where :

Wt = quantity of waste of type 't', and
r = methane recovery factor, applied in the case of landfill waste .

There are two methods for calculating greenhouse gas emissions in the waste sector – the Methane Commitment method and the Waste-in-Place method. The Methane Commitment method quantifies the net lifetime greenhouse gas emissions from waste deposited in the active year. In the Waste-in-Place method, CACP calculates emissions based on the amount of waste in the landfill less the amount of gas recovered. This method is appropriate for approximating the amount of gas available for flaring, heat recovery of power generation projects (CACP User Guide).

The CACP software uses the Waste Commitment method as the default because it provides results that can be used for comparison to the three 'R' measures. For example, reducing the amount of waste produced avoids all emissions that would have been released over the lifetime of the waste's decomposition. Therefore it is easier to account for all the emissions that will be either released or avoided in a year.

Appendix B

Data Sources and Assumptions

Data Assumptions Model output is dependent on data, and dependable output is generated from accurate data. For the Greenhouse Gas emission inventory the type of data that are required are not results of empirical research but from a variety of sources of socio-economic statistics on energy consumption and waste production. Since this study was the first of its kind for Baltimore County, data were not always available and assumptions had to be made. Assumptions are not uncommon in the GHG emissions inventory process (see the recent Maryland Climate Action Plan, August 2008). Data are often aggregated at national and state levels, not at city or county levels. While it has been common practice for organizations to track their costs for energy use in buildings, kWhs are not tracked. Governments and businesses will receive the benefit of more reliable, accurate and transparent inventory results if they take steps to track the necessary energy usage data.

The following are the data assumptions used for the inventory of Baltimore County for 2002 – 2006:

1) **Buildings Sector** – The County included within its organizational boundaries those facilities where administrative, police and fire, parks and recreation, and public works duties and operations occur. Libraries and Public Schools were not included. A list of facilities was compiled by Conni J. Smiddy, Lease Coordinator, Baltimore County Property Management, and included 104 buildings. This list also included some electric and heating oil and costs, as well as other indicators as operating hours and square feet (Table 9).

Energy usage data was as of FY 2007, and not originally planned to be included in the inventory. BGE supplemented the data on these buildings with gas (therms) usage (this is an extensive file with over 700 line items). A factor for energy used per County employee was derived with this data and applied to the number of employees working for the County during each of the years included in the inventory.

$$2006\ kWh = 2006\ employees \times \left(\frac{2007\ kWh}{2007\ employees}\right) \qquad (6)$$

The number of County employees was supplied by John Markley, Director of Finance and Budget for Baltimore County Department of Environmental Protection and Resource Management (DEPRM).

2) **Waster Water Pumping**– A file was received on June 11, 2008 from Wm. Frankenfield, Bureau Chief, Bureau of Utilities, Baltimore County Department of Public Works, that contained gallons of water pumped and cost for pumping. Estimates for kWh usage were based on data (gallons pumped and kWh used) from Baltimore City Back River Water Treatment, the City's water treatment plant.

$$2006\ county\ kWh = 2006\ county\ pumped\ (gals) \times \left(\frac{2006\ city\ kWh}{2006\ city\ pumped\ (gals)}\right) \quad (7)$$

3) **Streetlights/Traffic Signals** – Files were received from Greg Carski, Chief, Baltimore County Traffic Engineering, with data on streetlight kWh and cost and traffic signal cost. The traffic signal kWh were determined from streetlight kWh and cost.

It was challenging to retrieve data back to 2002 for streetlights and traffic signals as the accounting system has changed and emissions were estimated from total annual costs. Ideally, annual kWh should have been gathered before implementation of the program to accurately assess emissions reductions due to measures taken. However, the data that was provided on annual costs showed a decrease over time and was estimated that annual kWhs and GHG emissions were decreasing along with costs.

In 2006, the Baltimore Metro Council (Baltimore City and six surrounding Counties) formed a co-op of county governments and public schools for energy procurement and price stabilization. Member organizations can plan for energy costs with concern for fluctuations and uncertainty in the market. For this reason, estimations of kWh usage from annual costs may be less reliable in the future because energy and its costs are guaranteed in advance and will not reflect current market rates or trends. Increases and decreases in annual energy costs could potentially be due to prices negotiated the previous year and not reflect change in energy use. This strongly suggests the need to track energy usage for the emissions inventory process since it can no longer be assumed that decreases in County energy costs reflect decrease in energy usage. This is especially important for quantifying reductions from energy efficiency measures taken to meet the County's goals.

4) **County Vehicle Fleet** – Files were obtained from Robert T. Majewski, Vehicle Operations Administrator, Baltimore County Vehicle Operations and Maintenance, that contained the necessary data to determine the GHG emissions from County automobiles, light and heavy duty trucks. Data on heavy equipment was not included, as hours of operation, not miles, are tracked on this type of equipment. Lawn moving equipment was also not included.

5) **Employee Commute –** A survey was conducted of a small subset of County employees (DEPRM staff) and estimations of total employee commute miles and commuting methods were made from the respondents replies (82 out of 110 staff). This is a small sample on which to estimate the commuting patterns of over 8000 County Employees, but it was agreed upon by David Carroll, at the time Director of DEPRM and currently Director of the Baltimore County Office of Sustainability. In addition, by selecting the DEPRM staff as survey participants a bias may have been introduced for people who intentionally choose to live closer to work or choose alternative methods for commuting. Overall, the value used for employee commuting miles may be underestimated.

The results of the survey indicated that 88% drive alone, 2% use Mass Transit, 6% walk/bike, and 4% carpool. Also, the weekly commute is about 133 miles. The total annual mileage was calculated by multiplying these percentages times 133 miles per week, times 48 weeks. For example:

$$Total\ miles\ for\ commuters = 0.88 \times \#\ employees \times 133\ \frac{mi}{wk} \times 48\ wks \quad (8)$$

This was done for mass transit and carpooling (not for walk/bike) but the occupancy factors (10 for mass transit, 2.5 for carpooling) were also factored into those calculations. For example, if there are 100,000 miles from employees' mass transit commute and the occupancy factor on a bus is 10, then only 1/10 of those emissions are attributed to each rider. Therefore only 10,000 miles are counted towards the total employee mass transit miles.

6) **Waste –** No data exists on the amount of trash generated by County Operations therefore estimates were made by averaging two methods for calculating solid waste generated in office buildings, one based on total number of employees and the other based on total square feet of office space. These methods are described in a report by Department of Sanitation New York, Commercial Waste Management Study, March 2004. The number of County employees was given in an e-mail from John Markley. The number of square feet was determined from the file with the buildings' data. http://www.nyc.gov/html/dsny/downloads/pdf/swmp/swmp/cwms/cwms-ces/v2-cwgp.pdf.

7) **Other Sector –** No data were gathered for this sector.

Appendix C

Revision History

Date	Version	Name	Description