Greenhouse Gas Inventories of Baltimore County and County Government

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ABSTRACT

Inventories of Greenhouse Gases (GHG) were conducted for Baltimore County and for Baltimore County Government Operations using The Clean Air and Climate Protection Software developed for the International Council for Local Environmental Initiatives. The inventory focused on carbon dioxide, methane, and nitrous oxide. The years inventoried were 2002 to 2006, and projections were made for business as usual conditions for 2012. Targets for 10% reduction of the base year (2006) emissions by 2012 were derived.

In 2006, Baltimore County produced 11.5 million metric tons (MMt) eCO_2. The Transportation Sector contributed the most with 4.9 MMt (42%), followed by Residential Sector with 3.2 MMt. Electricity is the greatest source of emissions (39.9%) followed by gasoline (35.0%). In comparisons with other jurisdiction, parallels were observed in emissions' sectors and sources. Variations in per capita comparisons may be due, in part, to the fuel mix used in local electricity generation.

Baltimore County Government General Operations inventoried activities produced 1.24% of the total County emissions, 142.7 Thousand Metric tons (KMt) eCO_2 in 2006, with Buildings contributing 39.6 KMt, followed by Waste Water pumping, 38.6 KMt. The largest sources of emissions for County operations were electricity (62.4%) and gasoline (30%). Baltimore County Government's pattern of energy use and emissions production shares similarities with other jurisdictions with Buildings, Waste Water pumping, and Vehicle Fleet contributing the highest emissions.

INTRODUCTION

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, 1997). 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 physio-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.

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.

In the past, efforts to identify and 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 has developed the State Inventory Tool (SIT) to assist them. In 2001, Maryland conducted their first emissions audit for the year 1990, the Kyoto Protocol base year. 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.

When this study was initiated in fall 2007, there was no firm federal commitment to reduce greenhouse gas emissions. However, under the guidance of Governor O'Malley, Maryland has taken steps in this direction, by signing onto the Regional Greenhouse Gas Initiative, a CO_2 cap-and-trade program (Ulman, 2008) and 'EmPOWER Maryland'(Farris, 2008), a commitment to reduce the state's energy requirements. In the summer of 2008 the State completed its updated GHG emissions inventory, set goals for emissions reductions and developed a climate action plan to meet those goals (Roylance, 2008). Baltimore County established its own Sustainability Network to address the issues of energy efficiency and sustainable action within its own operations with preliminary recommendations expected in spring 2009. The County willingly supported the research reported here, the first GHG inventory for Baltimore County, 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.

BODY

Greenhouse Gas Inventory Methods

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* (CACP) 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 in the local region. 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.

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, seen in Table 1, such that one unit mass of Methane is 23 times more potent than an equal mass of Carbon Dioxide in atmospheric forcing and Nitrous Oxide 296 times more potent.

Table 1. Global Warming Potentials, IPCC, Third Assessment Report, 2001.

GHG	100 Year GWP
CO_2	1
CH_4	23
N_2O	296
IPCC Third Assesment Report 2001	

The CACP software program 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.

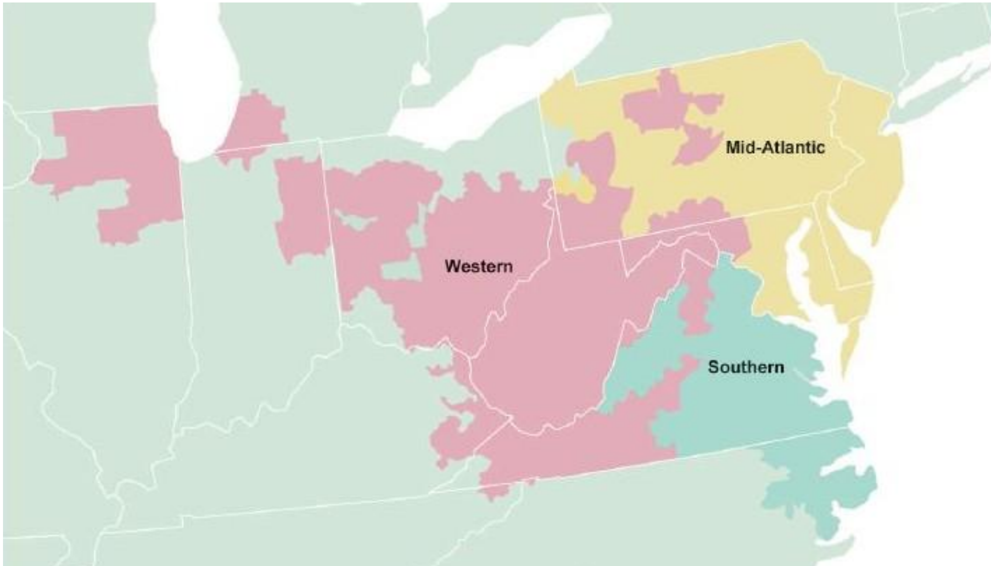
<u>Baltimore County Community Inventory</u>

The Community Analysis Module was used for the emissions inventory of all Baltimore County activities. A range of years, 2002 – 2006, was inventoried to uncover any trends or aberrations (i.e., weather) that may exist and 2006 was chosen as the base year, modeled on the Maryland Climate Action Plan. The Module considers emissions from six sectors – Residential, Commercial, Industrial (RCI), Transportation, Waste and Other. Energy use and waste data were entered into the inventory database as records. Depending on the level of data aggregation, a record can designate a single unit or a group. For example, data supplied by Baltimore Gas and Electric (BGE) aggregated all Residential accounts into one rate class, and was entered as one record.

● RCI Sectors - The Residential Sector covers all household fuel and electricity use. The Commercial Sector covers the fuel and electricity use that takes place in non-Residential buildings, including government and institutional activity as well as commercial and personal services. The Industrial Sector covers the fuel and electricity used by industrial establishments. For these three sectors, the key data was energy consumption from BGE records and the Energy Information Administration (EIA).

Baltimore County is part of the PJM Interconnection, depicted in Figure 1, a Regional Transmission Organization that dispatches and coordinates the flow of bulk power across the District of Columbia and all or parts of 13 states, including Maryland (PJM, 2007).

Figure 1. PJM Interconnection Region.



The mix of fuel sources that are used in electric generation in the PJM region has a direct effect on the amount of GHG emissions that are associated with the production of electricity in our region. In 2006 in the PJM region energy suppliers used 57% coal, 35% nuclear, 5% natural gas and 1% hydropower to produce electricity, shown in Table 2. These percentages change over time depending on availability of fuel, energy requirements and the State's renewable portfolio standard. In this way the PJM system mix influences the GHG emissions of Baltimore County. (NO_x and SO_2 are criteria air pollutants and not part of this study).

Table 2. PJM Interconnection Fuel Mix and Emissions, 2006.

PJM Interconnection Fuel Mix, 2006				
Fuel	% by Fuel	CO2	NOx	SO2
Captured Methane - Coal Mine Gas	0.01	0.133	9.6E-05	1.8E-07
Captured Methane - Landfill Gas	0.14	0.302	3.7E-03	5.1E-04
Coal - Bituminous and Anthracite	50.37	1013.154	1.8E+00	7.5E+00
Coal - Coal-based Synfuel	0.30	7.730	1.7E-02	1.2E-02
Coal - Sub-Bituminous	5.16	117.486	1.8E-01	3.0E-01
Coal - Waste/Other	1.65	36.702	1.2E-01	1.4E-01
Gas - Natural Gas	5.14	64.394	4.7E-02	1.2E-02
Gas - Other	0.00	0.077	9.2E-05	2.9E-05
Hydro - Conventional	1.12	0.000	0.0E+00	0.0E+00
Nuclear	34.98	0.000	0.0E+00	0.0E+00
Oil - Distillate Fuel Oil	0.07	1.446	3.8E-03	1.7E-03
Oil - Jet Fuel	0.00	0.002	4.7E-06	5.4E-06
Oil - Kerosene	0.00	0.076	2.5E-04	6.9E-05
Oil - Residual Fuel Oil	0.23	4.455	7.2E-03	1.9E-02
Oil - Waste/Other Oil	0.00	0.048	1.2E-04	3.7E-05
Solid Waste - Municipal Solid Waste	0.57	5.627	2.6E-02	2.8E-03
Wind	0.12	0.000	0.0E+00	0.0E+00
Wood - Black Liquor	0.04	0.105	1.0E-03	3.6E-04
Wood - Wood/Wood Waste Solids	0.10	0.015	2.3E-03	1.1E-04
Total	100	1251.750		

● RCI Emission Factors - 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, 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 coefficients, based on fuel types and technology 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, 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.

●Transportation Sector - For the Transportation sector (which includes all the fuel use associated with the on-road movement of goods and people), the number of vehicle miles traveled was gathered from Maryland State Highway Administration. These values were combined with default values for each vehicle type and fuel combination to calculate emissions.

●Transportation Emission Factors - 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:

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

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

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

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 persons 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 miles 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.

(3) $$\left. Emissions \middle/ VMT \right. = fuel\ efficiency \times emission\ per\ fuel\ unit$$

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

(4) $$CO_2 Emission = \left(A/B\right) \times C \times D \times E$$

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 several 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 < 8500 lbs;
LDGT - light-duty gasoline trucks; vehicles with GVW < 8500 lbs;
HDGV - heavy-duty gasoline vehicle; vehicles with GVW > 8500 lbs;
LDDV - light-duty diesel vehicles; passenger cars with GVW < 8500 lbs;
LDDT - light-duty diesel trucks; trucks and vans as described for LDGT;
HDDT - heavy-duty diesel trucks; larger heavy 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.

●Waste Sector - Information used for the Waste Sector came from the Baltimore County Department of Public Work, Solid Waste Management, and included the amount of waste generated by Residential and Commercial sectors (Industrial sector waste is sent to private landfills and not reported) and allocated to the various waste management alternatives, and an estimate of the percent of methane recovered (if any).

●Waste Emission Factors - Greenhouse gas emissions 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 CH_4/ ton waste	Methane Factor
B	eCO_2 sequestered / ton waste	Site Seq

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

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

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 (reduce, recycle, reuse). 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.

●Other Sector - The final sector, Other, includes greenhouse gas emission data not covered in the other sectors, for example the emissions of HFCs, PFCs or SF_6. For this inventory, there were no data available for this sector.

Baltimore County Government Inventory

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

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. Emission factors are similar to those used in the Community Inventory.

● Buildings, Streetlights and Waste Water - Data on energy usage in these sectors 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 wastewater output were included whenever, possible.

●County 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 above for additional details on the transportation sector default values and emissions factors). Heavy equipment and lawn mowing equipment were not included.

●Employee Commute - Emissions for this sector 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). 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. 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. 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. No GHGs from this sector are included in this study.

Results

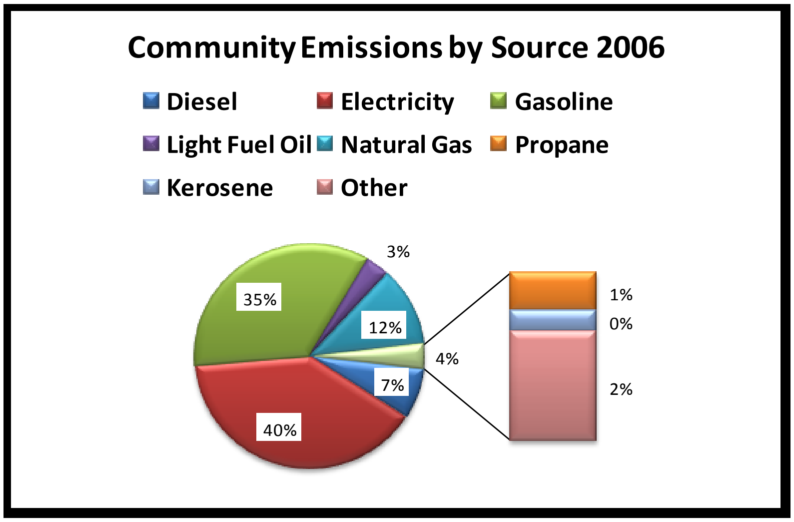
Baltimore County Community GHG Emissions

We estimated that Baltimore County generated 11.5 MMt of eCO_2 in 2006, results shown in Table 3. Transportation was the largest contributor followed by the Residential, Commercial, Industrial and Waste Sectors. As depicted in Figure2, electricity is the largest source followed by gasoline and natural gas.

Table 3. Baltimore County GHG Emissions, 2002 – 2006.

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

Figure 2. Baltimore County 2006 Emissions by Source.



During the period 2002 – 2005, emissions rose 6.1% from 11.4 MMt to 12.1 MMt but decreased in 2006. Throughout the five year period, Transportation Sector remained the major contributor, ranging from 4.76 MMt eCO_2 in 2002, to a high in 2005 of 4.90 MMt eCO_2, and dropping slightly in 2006 to 4.89 MMt. This drop is discussed later as likely due to increased gasoline prices. Emissions from the waste sector remained stable during the period and contributed the least emissions. The GHG emissions from the three sectors, Residential, Commercial and Industrial, also rose gradually for 2002 through 2005 and also experienced a slight drop in 2006, but maintained their positions as 2^{nd}, 3^{rd}, and 4^{th} largest emitters amongst the sectors. The drop is also likely attributable to increased cost of electricity.

Business as usual emissions for the target year 2012 will be 12.0 MMt, based on projected population growth of 0.7% (Baltimore County Department of Planning estimate). However, if the County desires to reach the target of 10 % reduction of the base year emissions, total emissions need to drop to 10.39 MMt eCO_2, or a decrease of 1.15 MMt eCO_2 produced in 2012. Suggestions on how to achieve this reduction are given below.

Baltimore County Government GHG Emissions

In 2006, the activities inventoried for Baltimore County General Government Operations generated 142.7 KMt eCO_2, and results are shown in Table 4. The Buildings Sector, which included 104 buildings, produced the most emissions, followed by Waster Water Pumping, Employee Commute, County Vehicles, Streetlights, and Solid Waste. During the 5 year period from 2002 to 2006, the Government GHG emission were dominated by Buildings, which remained stable, and Waste Water, which decreased as the volume of pumped water decreased. Vehicle Fleet, Employee Commute, and Waste Sectors remained stable throughout the period.

Table 4. Baltimore County Government GHG Emissions, 2002 – 2006.

Year	2002	2003	2004	2005	2006
Buildings	38,995	39,588	39,836	40,234	39,629
Vehicle Fleet	20,537	18,659	19,208	19,553	20,162
Employee Commute	24,649	24,770	24,697	24,741	24,820
Streetlights	20,278	20,134	19,983	19,793	18,854
Water/Sewage	44,785	41,016	44,624	40,439	38,665
Waste	558	563	565	568	572
Total Mt eCO2	149,802	144,729	148,913	145,327	142,701

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 as a whole. The BAU estimate of 148 KMt eCO_2 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. Suggestions for reductions are given below, and overall will consume the attention of the County's newly formed Sustainability Network.

Discussion

Baltimore County Community

The Community Emissions increased 5.7% during the period 2002 through 2005, from11.4 MMt eCO_2 to 12.1 MMt, and then declined in 2006 to 11.5MMt. During this period, the county population grew from 768,697 to 787,762 (2.5%), and per capita income rose to $43,022 (Bureau of Economic Analysis). Total GHG emissions increased faster than the County population (5.7% compared to 2.5%, as per Baltimore County Planning Office), from 2002 to 2005, before declining in 2006, shown in Table 5.

Table 5. Baltimore County Per Capita Emissions, 2002 – 2006.

Year	2002	2003	2004	2005	2006
Metric Tons eCO_2	11,423,490	11,687,033	11,891,774	12,091,254	11,548,267
Population	768,697	774,811	780,022	782,885	787,762
Per capita emissions	14.86	15.08	15.25	15.44	14.66

The Transportation Sector contributed the largest portion of total emissions in each period, and driving patterns may play a role. County VMTs increased from 7.8 billion miles in 2002 to 8.3 billion in 2006, or 28.8 VMT/person/day, compared to 27.6 VMT/person/day nationally (Bureau of Transportation Statistics, 2006), despite gasoline costs increasing from $1.15 in Jan. 2002 to $2.38 in Dec. 2006 (EIA). The 2006 American Community Survey of Baltimore County indicates that County commuters have a longer commute to work than the average U.S. worker (27.8 minutes vs. 25.5 minutes), which is noteworthy since 80% of County residents live inside the Urban Rural Demarcation Line (URDL) and may be expected to live closer to work. They also have a higher percent of drive alone drivers than the average U.S. worker (79% vs. 75.7%), and fewer commuters carpool (9.6% vs. 12.2%). According to the County Master Plan 2010, County residents spend 31 hours a years in traffic congestion, up from 13 hours annually in 1982, contributing significantly to air quality problems (non-attainment for ozone) in the region (Choi, 2004). Examining driving patterns of County residents, therefore, reveals areas for reducing VMTs and lowering GHG emissions, such as carpooling.

The rising gasoline cost may prove a sufficient motivator for change, as was seen recently in Maryland. In The Baltimore Sun article on Oct. 14, 2008, “Living at $4.00 a gallon”, it was noted that ‘the number of miles driven by vehicles in Maryland during June (2008) dropped by nearly 5 percent, compared with a year ago, according to federal highway statistics’ (Kay, 2008). However, this trend must be followed as gasoline prices have dropped since the end of the summer to 2006 levels, and efficient driving patterns may be affected. A combined effort by residents and elected officials is required to answer the transportation challenges and reduce emission from this sector.

Energy used in buildings generated the next largest amount of GHG emissions in the County. Household electricity usage grew, from 3.5 billion kWh in 2002 to 3.8 billion kWh (8.6%) in 2005. The larger gas and electric rate classes also experienced increased usage, 10% for the Commercial sector and 13.9% for the Industrial sector. However, in 2006, total County GHG emissions decreased almost 5% from 2005 levels, possibly due to an event that impacted the broader region. Utility rate caps, part of deregulation in 1999, kept customers’ utility costs artificially low until the summer of 2006 when BGE customers received a 72% rate hike. Emissions from electricity and gas usage in the Residential, Commercial and Industrial Sectors declined in 2006, 9.5%, 5.9% and 6.1% respectively likely due to the increased costs of energy.

Increasing the cost of energy (electricity) may initially provide the impetus to use less energy and lower emissions. Per capita emissions in 2006 were almost 0.8 MMt eCO2 lower than the previous year (14.66 vs. 15.44). But will behavioral changes made by consumers in the face of rising energy costs become habits? Preliminary data analysis for 2007 show a 3.4% rise in electricity consumption in the Residential sector, and to a lesser degree in the Commercial and Industrial sectors for 2007. It may be too soon to make predictions.

The system mix in electricity production can vary annually depending on the type of fuel used, some types have higher energy density and thus less CO_2 emission per MWh. Table 6 shows that in 2005, the PJM system fuel mix produced 1292 pounds of CO_2 per MWh generated, and in 2006, 1251pounds (3% decrease). The decrease in Baltimore County GHG emissions from 2005 to 2006 may be attributed to the rate increase, but at least, partially to the CO_2 emission factor from the system mix. Ramaswami et al. (2008) agree that “The magnitude of the community wide emissions (and hence the per capita) is most sensitive to changes in the emissions factor for electricity”.

Table 6. PJM Fuel Mix and CO_2 Emission Factors, 2005, 2006.

	2005		2006	
Fuel	**% by Fuel**	**CO2**	**% by Fuel**	**CO2**
Coal – Bitu/Anth	49.76	1008.52	50.37	1013.15
Coal - based Synfuel	0.22	6.23	0.29	7.730
Coal - Sub-Bituminous	5.66	**133.00**	5.16	**117.49**
Coal - Waste/Other	1.60	35.23	1.65	36.70
Gas - Nat Gas	5.35	67.14	5.14	64.39
Gas - Other	0.004	0.08	0.003	0.08
Hydro -	0.92	0.0000	1.12	0.000
Nuclear	34.12	0.0000	34.98	0.000
Oil - Distillate Fuel Oil	0.41	**9.58**	0.068	**1.45**
Oil - Jet Fuel	0.00004	0.0010	0.00010	0.002
Oil - Kerosene	0.01010	0.1552	0.00408	0.076
Oil - Residual Fuel Oil	1.10	**25.86**	0.23	**4.46**
Oil - Waste/Other	0.00025	0.0057	0.00208	0.048
CO2 Emission Factor		**1,292.02**		**1,251.75**

This, combined with the decrease in consumption, produced almost 5% reduction in GHG emissions for Baltimore County from 2005 to 2006. It is interesting that Maryland has set a goal of 10% reduction of base year GHG emissions by 2012 in their recently released Climate Action Plan. One year of reduced usage and higher density fuel combined to produce half of that goal, clearly demonstrating these are both appropriate avenues to explore when planning for climate change mitigation.

The solid waste sector showed a unique pattern during the time period measured. The area experienced an extreme weather event, Hurricane Isabel in September 2003, causing 3.3 million customers to lose electricity in the region and more the $400 million in federal insurance claims (Green, 2004). The damage from this storm caused an increase in the amount of solid waste generated (demolition materials) and an increase in emissions from solid waste (7.1%) during 2003–2004, although waste contributes less than 2% to overall emissions. As recovery from the damage was completed, by 2005, the tonnage of waste and the emissions attributed to solid waste decreased to below 2002 level.

Baltimore County has a number of contractual agreements for disposal of its solid waste. In 2006, over 750,000 tons of solid waste were collected from Residential and Commercial sectors, directed to one of three disposal sites, and included in the emissions inventory:

1) Eastern Sanitary Landfill - 160,000 tons, type D (lined), where a landfill gas-to-energy system produces 3 MW electricity per day;

2) BRESCO (Baltimore Southwest Resource Recovery Facility) - 165,000 tons, municipal waste to energy;

3) Sent out of State - 430,000 tons to Type D landfills.

Total solid waste generated 166 KMt eCO_2 in 2006. Not included were possible emissions from 8 landfills that are closed but, since methane can be emitted for up to 30 years, may still be emitting some GHG. Over 700,000 tons of materials were recycled, which represents 1.7 MMt of eCO_2 avoided by reduction of methane in landfill and upstream avoidance of production from raw materials.

There were no entries in the Other Sector because of lack of available data. However there are activities that merit further investigation such as the gas and diesel fuel sold in County's 17 marinas. Approximation of Baltimore County's emissions from major industrial polluters can be made from the recently published Maryland Inventory of GHG Emissions. Baltimore County has approximately 2% of the State's industrial employees (Maryland Department of Labor, Licensing and Regulations), therefore the County could be producing (0.02 · 5.4 MMt eCO_2 State's emissions from industrial processes) or 0.100 MMt eCO_2 from the Industrial sector. These are areas that should be considered in subsequent emissions inventories.

<u>Baltimore County Government General Operations</u>

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 except County vehicles. 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. 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).

Government Buildings generated the most emissions of the sectors included. As previously stated, the Government's Buildings sector included 104 buildings, which are owned or leased by the County. There are over 2.7 million square feet, and almost $6 million spent annually on energy. 54.5 million kWh electricity generated 31.2 KMt CO_2, 934k therms of natural gas generated 5.1KMt eCO_2, and 273,000 gallons of heating oil generated 2.9 KMt. Emissions in buildings rose slightly over the first 4 years, then dropped in 2006 (1.5%), likely attributed to similar reasons for the decrease in the Community. Brodsky (US EPA) states that modifying occupant behavior can reduce energy use and emissions from buildings by 3-15%, therefore this sector may present opportunities for County to meet its short-term target of 15% energy and 10% GHG reductions.

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), as shown in Table 7, and may provide another opportunity for energy reduction in buildings.

Table 7. Sample of Variation of Electricity Cost per ft^2in Government Buildings, 2006.

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 certify data accuracy it is necessary to have multiple sources for comparison. The sole opportunity during the inventory process occurred with data on energy use in buildings. Kilowatt hours used in County Government Buildings were obtained from Baltimore County Bureau of Building and Equipment Services and BGE. The data, seen in Table 8, compare favorably, with less than 6.5% variation, with one exception. Differences may arise from calendar year (BGE) and fiscal year (County) based data.

Table 8. Sample of kWh data used in Baltimore County Buildings, from BGE and Baltimore County Bureau of Building and Equipment 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**

Emissions from the Solid Waste, County vehicle and Employee Commute Sectors were stable from 2002–2006. Solid waste, estimated at 2400 tons, generated 0.57 KMt eCO_2. An additional 300 tons of paper and other materials were recycled.

County vehicle fleet 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. To reduce fuel costs and GHG emissions, the County 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. See results of comparisons in Table 9. As hybrid technology becomes more affordable and extends successfully to full size vehicles, converting the fleet to hybrid vehicles will 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

Employee commute emissions were based on a survey of driving patterns of DEPRM staff (82 respondents out of 110) and tallied 24.8 KMt eCO_2 from 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 employees of the environmental protection department may have been more likely to choose to live close to work or use alternate transport at a higher rate than other employees, but the survey provides a good estimate for County Employee Commute. In September 2008 the County initiated a Rideshare Program for County Employees interested in carpooling. Based on the results of the survey, over 30% of employees are interested in the program, which would provide an excellent opportunity for reduction of emissions from this sector.

Most of the decrease in County Operations GHG emissions from 2005 to 2006 can be attributed to the streetlight/traffic signal sector (4.7% decrease) and waste water pumping (4.4% 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 250 signalized intersections (2.3 million kWh and $250,000). In 2002, the County began a two phase program of switching to energy efficient technology in its 250 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. 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 were provided on annual costs showed a decrease over time and was it 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.

Emissions from the Waste Water Sector 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. This sector is the second largest emitter of GHG in County Operations but demonstrates that emissions reductions are achievable by decreasing volume of water pumped. The County may want to further investigate the feasibility of decreasing waste-water volume to help met their goals for reductions.

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 heavy equipment operations. These omissions lead to the conclusion that the current inventory is an underestimation of the County's Government's GHG emissions.

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.

Comparisons with other jurisdictions

Comparisons were made with other communities, shown in Table 10, and governments, Table 11, to understand differences and similarities with Baltimore County. We expect that similarities should exist with nearby jurisdictions with similar demographics, and that for others, there should be identifiable reasons for differences. Care was taken to make comparisons with other jurisdictions that used the same inventory model to avoid differences inherent in different models.

Table 10. Per Capita Comparisons with Other Jurisdictions.

Jurisdiction	MMTon CO_2e	Year	***
	Per capita		
Baltimore County	14.7	2006	
Montgom. County, MD	13.5	2005	
Montgom. County, PA	17.0	2004	
Denver	25.3/19.1	2005	w/wo air travel
Seattle, WA	11.5	2005	8% below 1990
Maryland	19.6	2005	29% over 1990
USA	24.5	2005	16% over 1990

Montgomery County, Maryland, has characteristics that are similar to Baltimore County, but it produces 1.2 mTons eCO_2 per capita less than residents here. It is a suburb of a major metropolitan area, predominantly Residential and Commercial, with some Industrial businesses. The County has 100 square miles less than Baltimore County but approximately the same number of miles of roadways (3,000 in each County, MD State Highway Administration). The population, 900,000 is about 100,000 more than Baltimore County. A closer look at the inventory shows some interesting differences (See Appendix C for Montgomery County, MD Results).

First, the Residential and Commercial/Industrial Sectors generated 1.6 MMt eCO_2 more than Baltimore County, as is expected since there are almost 100,000 more residents. However, energy consumed and emissions factors that were used in the model are not stated and could reflect the per capita difference. Second, the Transportation Sector, the largest sector for both Counties, generated almost 0.6 MMt less in Montgomery County. Montgomery County had 1 billion less VMTs than did Baltimore County (MD SHA). To understand why this occurs one would have to examine commuting patterns (mass transit and carpooling) but the smaller size of the County, 100 square miles smaller than Baltimore County, could be a contributing factor. These two factors combined could cause the per capita emissions to be lower for Montgomery County, MD.

Montgomery County, PA, is a suburban county (Philadelphia), with 500 square miles, and 775,000 residents, and located in the PJM region. In 2004, the Montgomery County generated 17.0 MMt per capita,15% higher than Baltimore County. The Transportation sector contributes 43% to Baltimore's total emission and 25% to Montgomery County's. Total VMTs are not in the report so the smaller percentage could be due to fewer VMTs on Montgomery County's roads or another sector contributing a larger percentage of emissions. The second notable difference is the higher percent of energy used by the Residential, Commercial and Industrial (RCI) Sectors in Montgomery County compared to Baltimore (greater than 65% for Montgomery County, 57% for Baltimore County). The Larger Commercial/Industrial (LCI) Sector consumes significantly more electricity than the Residential or Small Commercial/Industrial (SCI) Sectors and most likely contributes to the per capita emission value that is considerably higher than Baltimore County where the Residential Sector is the largest energy consumer of the RCI Sectors.

The comparisons with Denver, CO, and Seattle, WA reveal once again the effect of the electricity system fuel mix on GHG emissions. In Denver, 1982 lbs of CO_2 are emitted for each MWh of electricity (75% fuel mix is coal); in Seattle, only 360 lbs are emitted (mostly hydroelectric); in Maryland, 1293 lbs (55% fuel mix is coal) according to EPA's data base for emissions factor from electricity, e-GRID. Higher emissions factors for electricity will contribute to higher per capita emissions. Denver's emission factor is 52% higher than Baltimore County's and its per capita emissions is 30% higher. Seattle's emission factor is 72% lower than Baltimore County's and its per capita emissions are 22 % lower.

In Denver, emissions from light trucks and SUVs surpassed emissions from passenger vehicles. According to the National Household Travel Survey (June 2006), trucks and SUVs together comprise 30% of personal vehicles, nationally. Since SUVs and trucks have lower fuel efficiencies and higher emissions, higher per capita GHG emissions are likely to be found.

The Denver inventory also includes emissions from airplane travel that can significantly increase GHG emissions for the region, in Denver's case by over 6 mTons per person (from 19.1 to 25.3). Air travel is not included in the Baltimore County inventory since the major metropolitan airport, Baltimore Washington International, is located in Anne Arundel County. This is a Scope 3 emission that should be included since many County residents use BWI, but determining the number of airplane passengers that live in Baltimore County may be challenging and demonstrates an obstacle in including Scope 3 emission in an inventory.

Finally, comparisons with the State of Maryland and the US show that Baltimore County residents have lower per capita emissions, but a few points need to be made to qualify this comparison. First, more comprehensive methodologies (such as SIT) are used for state and national level inventories that are based on IPCC recommendations and used for national and international comparisons. These inventories include emissions from off-road transportation, mining activities, agriculture and electricity transmission. Second, data from industrial processes (i.e., ozone depleting substances) are readily available at, and included in, the state and national level emissions inventories. Both of these contribute to higher per capita emissions and make comparisons less meaningful.

Some similarities exist between the Baltimore County and Maryland inventories, specifically in the sources of emissions. Electricity is the leading source of emissions (39% in Baltimore, 42% in Maryland) followed by gasoline (34%, 22%).

Comparisons with other Governments, shown in Table 11, 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, Scope 3 sector (Staff Commute) emissions, while challenging to quantify, can be a significant part of a jurisdiction's inventory.

Table 11. Comparisons of GHG with other Governments**,** by Sector.

	% Emissions		
Gov't	Baltimore*	Annapolis	Durham
Buildings	27.8 (33.7)	27.5	47
Vehicle Fleet	14.1(17.1)	31.8	16
Staff Commute	17.4 (0.0)	NA	NA
Streetlights	13.2(16.0)	10.3	8
Water/Sewage	27.1(32.8)	29.6	29
Waste	0.4(0.5)	0.7	<1.0
% Emissions	100(100)	99.9	100
* with(with-out) Staff Commute			

<u>Scenarios for Reductions</u>

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. Baltimore County has decided to follow the State's lead, and has 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. However, such a comprehensive analysis exceeds the scope of this project but, for County Government Operations, this will be 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 transportation sector, as the largest emitter in the Community, provides opportunities for reductions in energy use and GHG emissions reductions. First, the recent rise in the gasoline cost per gallon produced a 5% reduction in VMTs on the road in Maryland. Equating this to the County level means 415 million fewer miles and 239,000 fewer tons of eCO_2 per year from the Transportation Sector, or 20% of the reduction goal (1.15 MMT eCO_2) for Baltimore County with no out of pocket expense for energy efficient technology, (although fuel costs are high) and results from changes in behavior, such as planning efficient driving, using mass transit and carpooling. However, the ease of gas pricing has seen an erosion in these savings. Additional reductions could come from increased fuel efficiency. If 10% of the SUV/ Light Truck miles (2.6 billion miles or 22,000 vehicles) would change to mid-sized autos, then a reduction of almost 63,000 tons of eCO_2 (5.5% reduction goal) would be realized, in addition to $800 per year per vehicle in fuel costs savings (increased efficiency from 14 mpg to 21mpg, 12,000 miles per year, $3.00 per gallon). Further reductions could be realized from this sector by increasing mass transit and carpooling.

The Residential Sector, as the second largest emitter, also provides many opportunities for energy efficiency, reductions and emissions savings. Using compact fluorescent light bulbs is an easy step that every household can take to reduce energy and lessen GHG emissions. If 300,000 households in the County replaced 10 bulbs, then the initial cost would be approximately $3.00 per bulb ($30.00 per household) but this measure would save each household 840 kWh and $92.00 annually in electricity cost ($0.11/kWh) and the Community over 145,000 tons eCO_2 or 12.6% of the target reduction in emissions.

Finally, the EPA states that occupant behavior in commercial buildings could affect the energy used there and modifying that behavior could result in saving of 3 - 15% per year in energy costs and emissions. Changing employees' behavior could decrease energy usage by 5% in the commercial sector (BGE small commercial class) and lead to a reduction of 33,000 tons eCO_2 from using 44 million less kWh electricity and 1.7 million fewer therms natural gas.

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 ton 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 program.

Reductions from Waste Water Sector could be realized by Community participation in source reduction. The American Water Works Association 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, then GHG emissions would be reduced by 3,866 tons or 27% of the target for reduction. Community and/or County Government would incur material and installation costs from this reduction, but electricity production for Waste Water pumping is a major emitter and some measures for emissions reductions are likely to arise from this sector to meet the reduction goals.

Finally, the Employee Commute Sector contributes the third largest amount of emission to Government Operations. The results of the Employee Survey indicated that over 30% of staff was interested in a carpooling program. Recently, County Government established a carpooling program that offers additional benefits to participants, such as paid parking and a guaranteed ride home. If 10% of County employees participate in this program, then 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.

Suggestion for Improving Subsequent Inventories

In the next County wide inventory the following items should be considered for inclusion, if data are available:

1) Biogenic sources and sinks of emissions including wetlands, forests, and animal emissions;
2) Off-road transportation: airplane, marine, railroads;
3) GHGs from industrial processes, such as ozone depleting substances;
4) Methane from the County's closed landfills;
5) Energy embedded in food consumed (Scope 3);
6) Energy embedded in other urban products (fuel, cement) (Scope 3);
7) Separate out miles from travelers passing through the County;
8) Air travel by County residents (Scope 3);
9) Fertilizers used on lawns and in parks.

Additions to the County Government inventory could include:
1) Refrigerants used in County Buildings;
2) Fertilizers used on lawns and in parks;
3) Emissions from heavy equipment and lawn mowing equipment;
4) Survey on larger sample of County employees to determine commuting patterns.

CONCLUSIONS

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

It is, therefore, important to know what local emissions in Baltimore County are so that policies can be implemented that will lessen local impact. The appointed Baltimore County Sustainability Network can begin to develop an Action Plan of policies and practices that lessen the emissions generated by the Government Operations and serve as an example to the broader community of residents and businesses. Successful reduction of GHG will lower energy use and costs. Finally, there exist opportunities for advancing the quality of life in the County. Policies that address greenhouse gas reductions often decrease detrimental impacts on the environment, such as smog, haze and acid rain, particularly in large urban and industrial centers. Failure to account for these ancillary benefits could lead to under-assessment of the mitigation policies that affect GHGs (Burtraw et al., 2003).

National policy for emissions control may be adopted in the near future, but state policies and regulations for emissions reductions are in place. Local elected officials should know where sources and sinks exist in the county so that they can begin to re-evaluate policies and programs and set goals for emissions reductions. Citizens of Baltimore County should know the amount of greenhouse gas emissions for which they are responsible so that they can appreciate their specific impact. Knowledge can empower residents to accept responsibility for change. For example, since utility deregulation has come to

Maryland, consumers now have six choices for electricity suppliers. Residents can include emissions from fuel mix as well as price when deciding on an electricity supplier. In this way individuals can influence their emissions impact.

The emissions inventory provides Baltimore County with the tools to begin the tasks. Change can occur at the local level when people and organizations modify their behavior, change their activities, and employ different technologies (Kates, 1998).

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