Baltimore County Community Greenhouse Gas Inventory

Environmental Science and Studies Senior Seminar

Towson University

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Abstract

In a continuation of the effort by M.S. student Patricia Brady of the Towson University Environmental Sciences Graduate Program to inventory greenhouse gases emitted by Baltimore County and County Government, an inventory of the Baltimore County Community was conducted for the fiscal year 2012. Greenhouse gas inventories, which are represented in equivalent units of carbon dioxide (eCO_2), are critical in quantifying the impact upon the environment through anthropogenic processes. These inventories focus on gases such as carbon dioxide [CO_2], methane [CH_4], and nitrous oxide [N_2O]. The emission of these gases can be quantified through the measurement of primary sources for greenhouse gas emissions: energy usage and solid waste generation (Brady, 2008).

The totals for emissions of greenhouse gases by the Baltimore County Community in 2012 were 4,904,022 Metric tons (Mt) eCO_2 for energy consumption, 4,939,272 Mt eCO_2 for transportation, and 150,049 Mt eCO_2 for waste. Summing gives **a total of 9.9 Million Metric ton (MMt) equivalent CO_2 for fiscal year 2012 in the Baltimore County Community** (Figure 1). The 2006 fiscal year CO_2 equivalent value was derived to be 11.5 Million Metric tons. When comparing the two summation values of 2006 and 2012 there is an approximate 14 % difference. Last, it should be noted that while the EPA definition of energy usage includes transportation for this report we assess transportation as an independent component.

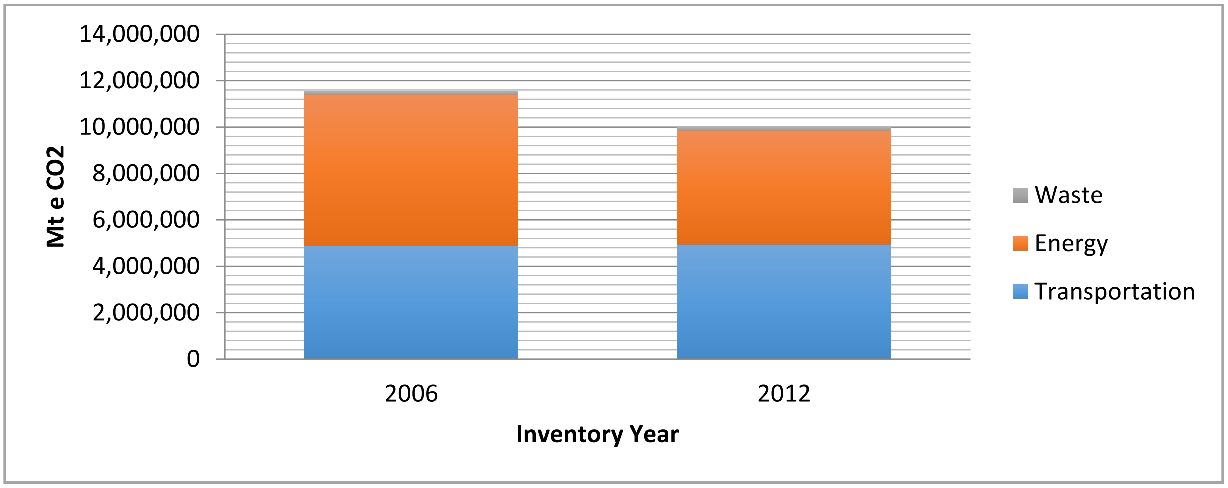


Figure 1 Comparative Review Graph of Fiscal Year 2012 eCO_2 Emissions Data versus 2006

1. Background

Maryland's population has increased from 5.3 million to 5.8 million inhabitants since the initial greenhouse gas (GHG) inventory published by Patricia Brady in 2008. We assume no further land use changes over this period. The background provided in the 2006 inventory provides significant detail of context to issues projected within this report.

2. Introduction to Greenhouse Gases and GHG Inventories

Greenhouse gases such as carbon dioxide, methane, and nitrous oxide are key factors in influencing anthropogenic climate change (IPCC, 2013). These gases act as an insulating layer in the atmosphere by absorbing long wave radiation that is emitted by the Earth's surface. These GHGs share a direct, positive, correlation with global temperature (EPA, EPA, 2014). When this temperature influencing energy, temporarily captured in GHGs, is thought of in terms of flow, pool size, and turnover time, it becomes apparent that by increasing the pool size (added GHGs in the atmosphere) while keeping energy flow the same, turnover time is increased. Therefore, it takes longer for this energy to escape into space. Since the short wavelength energy the Earth absorbs from the sun and reemits through long wave radiation is a measurable, relatively constant, input, it can be determined that the Earth is currently experiencing an energy surplus. It is without question that anthropogenic activity such as the burning of fossil fuels and biomass (carbon dioxide), the operation of industrial facilities, (nitrous oxide), and use of landfills and livestock flatulence (methane) emits copious amounts of greenhouse gases that have significantly influenced global temperatures. Countless studies have concluded that continuing emissions of GHGs will negatively affect environmental health in various ways (IPCC, 2013).

Conducting an inventory of these emissions allows entities, such as the Baltimore County Community to estimate their impact upon the environment. By isolating each source's specific emissions, community leaders and policy makers can more accurately influence change for the better. GHG inventories define the scope of each emission into three separate categories. This inventory included Scopes 1 and 2; Transportation and Waste categorized as Scope 1 and Energy as Scope 2.

3. Materials and Methods

The results from 2006 Brady Greenhouse Gas Inventory were used as a baseline comparison for the 2012 Baltimore County Community Inventory. Software used in 2006, Clean Air and Climate Protection, was not available for the 2012 inventory due to online licensing restrictions. Instead, emission numbers were calculated using standard emission factors provided by the U.S. Environmental Protection Agency and U.S. Department of Energy. This leaves room for discrepancy of comparable data due to differing GHG calculating methods between the 2006 and 2012 GHG Inventory.

3.1 **Transportation**

In order to quantify greenhouse gas emissions in equivalent units of carbon dioxide (MMt eCO_2), data for Baltimore County's Vehicle Miles of Travel (VMT) and greenhouse gas emissions from 2002 to 2006 were used from Pat Brady's thesis, including a calculated average conversion factor of

$$\mathbf{6.013 * 10^{-4}\ Mt\ eCO_2 / VMT}.$$

This equation was applied to the Baltimore County Community's VMT data from 2006 to 2012 (MDOT, 2013).

3.2 **Energy: Residential, Commercial, and Industrial**

The energy component is divided into three sectors: residential, commercial, and industrial. Each sector encompasses the fuel or electricity use for the county. The data were collected from Baltimore Gas and Electric, PJM Interconnection, Energy Information Administration, Baltimore County Department of Planning, and the Maryland State Government webpage.

PJM Interconnection is a regional organization that oversees the distribution of fuels across several states. They use a mix of fuel sources that are used to generate electricity as well as GHG emissions. These data are percentages of the fuels and are subject to change over time due to given variables, such as supply and demand. These variables allow for the GHG emitted to change as well. County level data were extricated from the Maryland State energy use tables based on the county, and EIA databases. These data were not complete for the 2012 fiscal year and therefore do not show the true results of carbon emissions so estimations had to be derived. The database for 2011 is complete and can show how the county has progressed since 2006. Furthermore, just the eCO_2 reported for energy in 2006 was extrapolated to calculate kilo watt hours for energy in the 2013 inventory.

Percent of residential, industrial, and commercial structures for the county versus the state used to calculate eCO_2 came from the Maryland Department of Planning offices. Kui Zhao of the Baltimore County planning office supplied the number of residences, commercial buildings, and industries located with the county. Mark Goldstein of the Baltimore City and State planning office supplied the numbers for the entire state. The numbers were then converted to percentages. County level energy use data were not available. This does throw off the precision of emissions calculated. The number wills most likely be lower or higher than what is presented. Better stated there will be a little variation.

	State data	County data	Percent %
Residential	2,157,717	321,000	14.88
Industrial	21,341	2,642	12.38
Commercial	143,680	18,391	12.80

Table 1 Maryland & Baltimore County Residential, Industrial, and Commercial Structures 2012

3.3 **Waste**

Tonnage of solid waste generated and sent to Baltimore County Landfills was necessary to determine emissions from the waste sector of the Baltimore County Community. To find the total tonnage of solid waste generated and sent to landfills in Baltimore County, contact was first established with the Department of Public Works. Correspondence with Michael R. Biechler, Bureau Chief of Solid Waste Management, resulted in data for the total tonnage of solid waste sent to landfills within the county for fiscal year 2012. No online conversion could be found; therefore, using the numbers reported in Brady (2008), we were able to determine a conversion factor from waste to eCO_2 (Table 2).

Year	Waste (tons)	Metric Tons of Equivalent CO2	Divisor
2002	738,721	165,713	4.457834
2003	790,031	177,180	4.458917
2004	769,146	174,389	4.410519
2005	702,757	159,402	4.408709
2006	732,219	166,805	4.389671

Table 2 Brady Calculations Table Representing Division Factors

4. Results

4.1 **Total Community Emissions**

Baltimore County Community emitted an estimated 9.9 Million metric tons of equivalent CO_2 for fiscal year 2012. The largest contributor for emissions was the Transportation sector followed by Residential Energy, Commercial Energy, Industrial Energy and Waste sectors. (Table 3/Figure 3)

Sector	Mt eCo_2
Transportation	4,939,272
Waste	150,049
Commercial	2,284,885
Residential	2,288,080
Industrial	331,056

Table 3 2012 Community Emissions by Sector

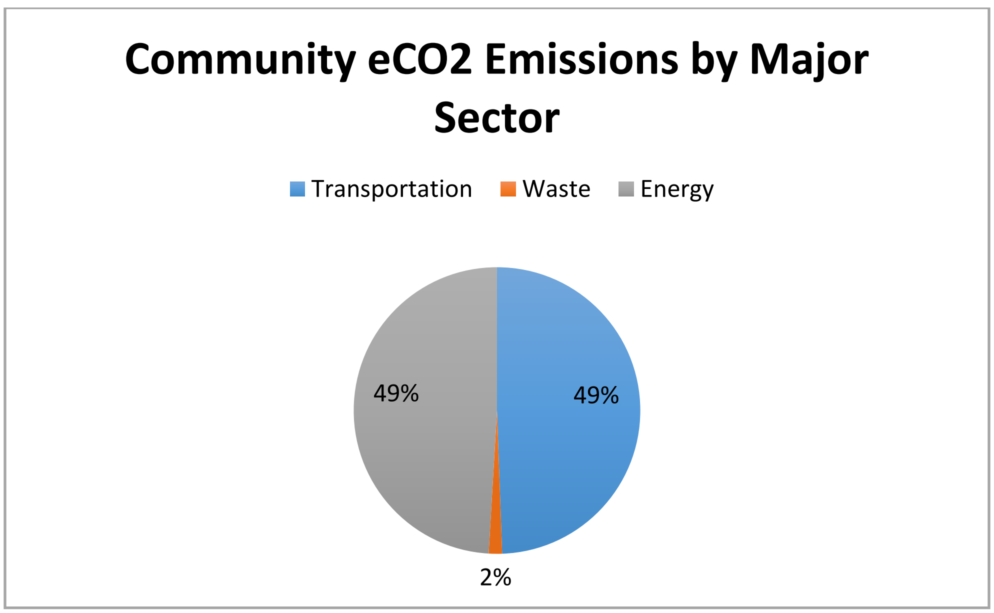


Figure 2 Chart Percent Analyses of Sector Emissions

4.2 **Transportation**

Baltimore County currently has an estimated population of 817,455, with 93% of people living in urban areas and only 7% living in rural areas (Bureau, 2014).The amount of equivalent CO_2 emitted in the Baltimore County Community area was 4,939,272 Mt eCO_2. Comparing the amount of Mt eCO_2 concluded in Pat Brady's report, which was 4,897,796, there was an increase of about 41,000 metric tons since 2006.

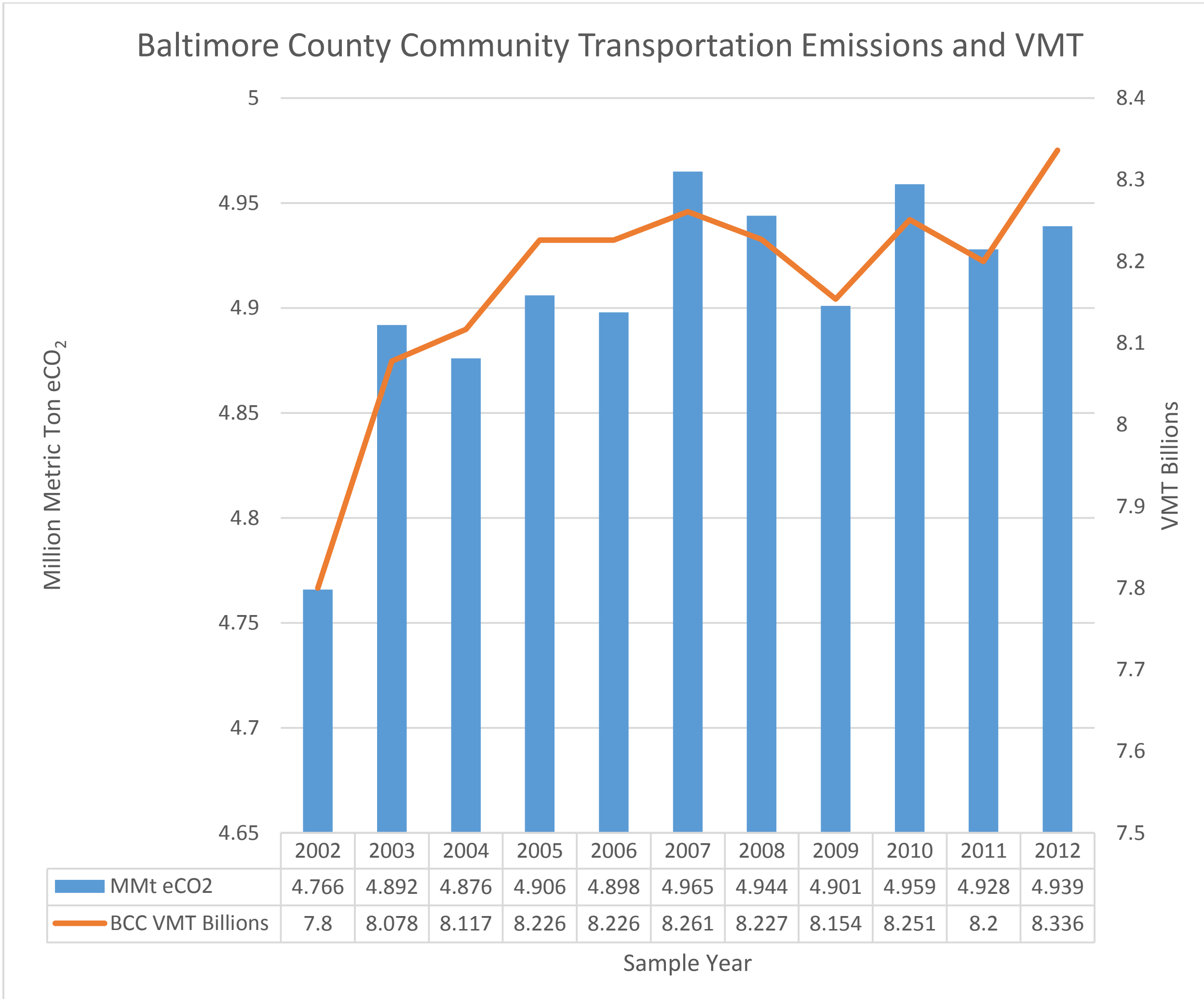


Figure 3 Baltimore County Community VMT and Emissions

4.3 **Energy**

From 2011 and 2012 the total energy utilized by Baltimore County's residential, commercial and industrial sectors were 8,585,534,564kWh and 8,276,831,083kWh respectively. These values equated to a total of 5,086,929 Mt eCO_2 in 2011 and 4,904,022 Mt eCO_2 in 2012. Residentially, the emissions were 2,405,547 Mt eCO_2 in 2011 and 2,288,080 Mt eCO_2 in 2012 for Baltimore County. Commercial emissions for Baltimore County in 2011 and 2012 were 2,313,779 Mt eCO2 and 2,284,885 Mt eCO2 respectively. The values derived for industrial sites were 367,602 Mt eCO_2 in 2011 and 331,056 Mt eCO_2 in 2012. (Tables 4, 5, 6 & 7) These data were only estimates made from the data that are available so far.

Baltimore County (2011)				
	Percent (%) to County	Trillion Btu	kWh	eCO2 metric tons
Residential	14.88	13.85328	4,059,995,585	2,405,547
Commercial	12.8	13.3248	3,905,113,386	2,313,780
Industrial	12.38	2.11698	620,425,593	367,602
Total		29.29506	8,585,534,564	5,086,929

Table 4 Baltimore County Energy Consumption 2011

State of Maryland (2011)		
	Trillion Btu	kWh
Residential	93.1	27,284,916,565
Commercial	104.1	30,508,698,329
Industrial	17.1	5,011,515,288
Total	214.3	62,805,130,181

Table 5 State of Maryland Energy Consumption 2011

Data Source: Energy Information Administration (EIA U. S., 2014)

Baltimore County (2012)				
	Percent (%) to County	Trillion Btu	kWh	eCO2 metric tons
Residential	14.88	13.5408	3,861,738,868	2,288,080.28
Commercial	12.8	13.1584	3,856,346,360	2,284,885.22
Industrial	12.38	1.90652	558,745,855	331,056.919
Total		28.60572	8,276,831,083	4,904,022.42

Table 6 Baltimore County Energy Consumption 2012

State of Maryland (2012)		
	Trillion Btu	kWh
Residential	91	26,669,467,319
Commercial	102.8	30,127,705,939
Industrial	15.4	4,513,294,469
Total	209.2	61,310,467,727

Table 7 State of Maryland Energy Consumption 2012 Estimates

Data Source: Energy Information Administration (EIA U. S., 2014)

4.4 **Waste**

It was found that the fiscal year 2012 yielded 334,288 tons of residential solid waste and 329,700 tons of commercial sold waste, bringing the total to 663,988 tons of total solid waste generated by the community. An average weighting factor of 4.42514 eCO2 per metric ton of solid waste was calculated. Using the weighting factor and the total solid waste generated within the community yielded a total of 150, 049 metric tons of eCO_2 emitted from landfills within Baltimore County for this year.

5. Discussion

5.1 Transportation

The transportation sector includes the movement of people and goods via cars, trucks, trains, ships, airplanes, and other vehicles. Carbon emissions from modes of transportation are major contributors of greenhouse gases. The majority of greenhouse gas emissions from transportation result from the combustion of petroleum. The largest sources of transportation-related greenhouse gas emissions are passenger cars and light-duty trucks, including sport utility vehicles, pickup trucks, and minivans, which account for over half of the emissions from the transportation sector (EPA, Sources of Greenhouse Gas Emissions, 2013). The remainder of greenhouse gas emissions comes from other modes of transportation, including freight trucks, commercial aircraft, ships, boats, and trains as well as pipelines and lubricants.

According to the EPA, transportation is the second largest contributor of U.S. greenhouse gas emissions, accounting for 28% in 2011. United States Greenhouse gas emissions from transportation have increased by about 18% since 1990. This historical increase is largely due to increased demand for travel as communities have moved farther away from city centers. The average number of vehicle miles traveled by passenger cars and light-duty trucks increased 34% from 1990 to 2011. (EPA, Sources of Greenhouse Gas Emissions, 2013) The increase in travel miles is influenced by factors such as population growth, economic growth, urban sprawl, and low fuel prices over much of this period. The third figure shows greenhouse gas emissions, measured in million metric tons equivalent CO_2 , from transportation from 1990 to 2011 (EPA, Sources of Greenhouse Gas Emissions, 2013)

According to the website, City-Data.com, Baltimore County Residents use eight different modes of transportation to travel to work. About 80% drive to work, 11% carpooled, 3% worked at home, 2% traveled via bus or trolley bus, 2% walked, 1% traveled via subway, and less than 1% traveled via streetcar or trolley car, railroad, ferryboat, taxi, motorcycle, bicycle, and other means (Figure 4).

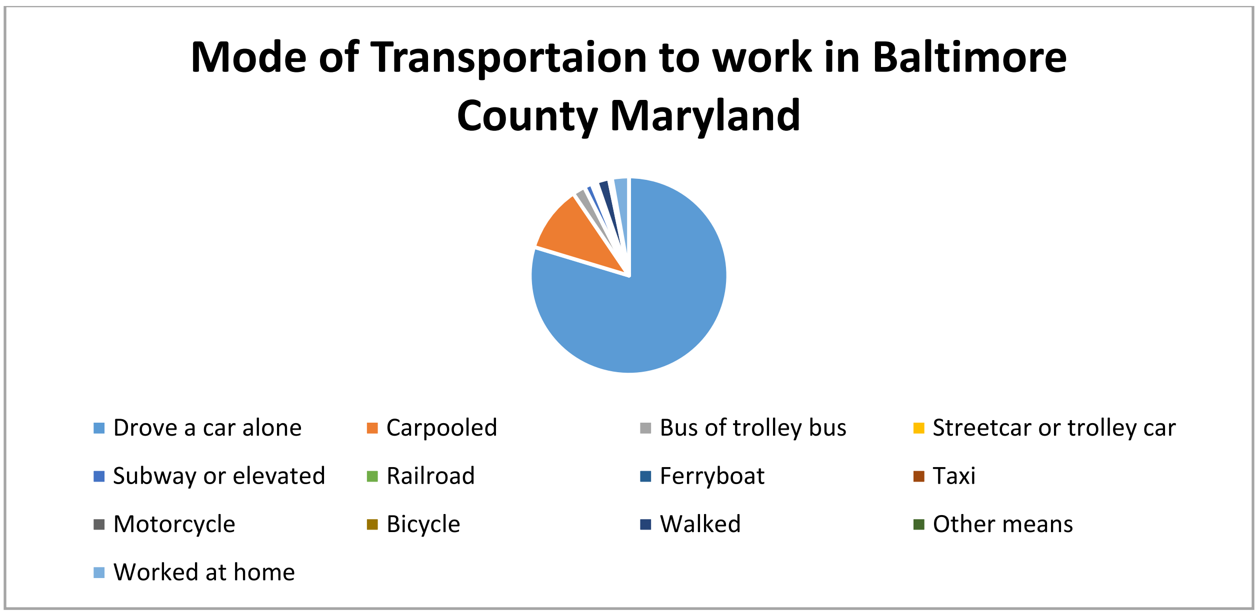
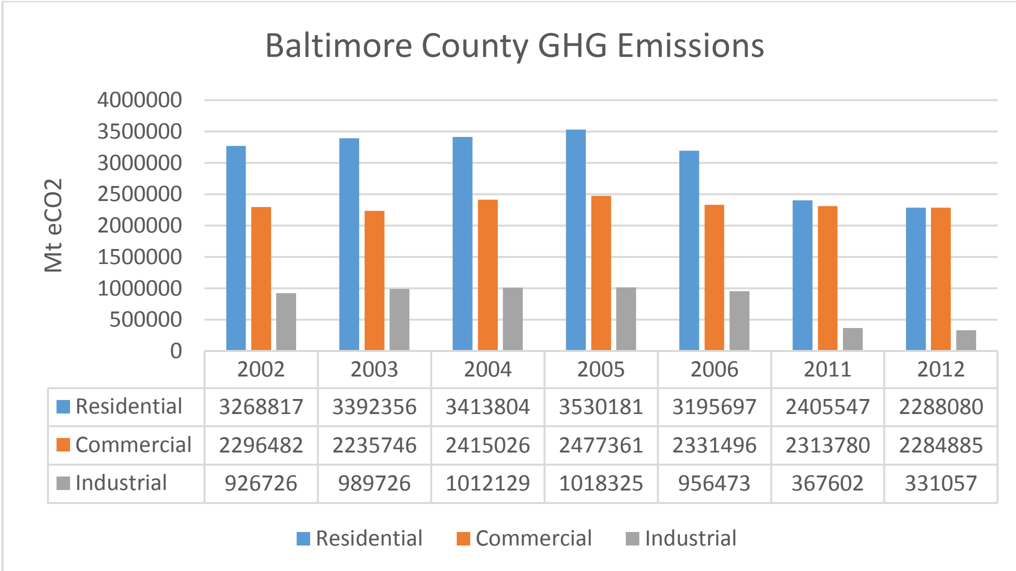


Figure 4 Transportation Modes for Baltimore County Workers

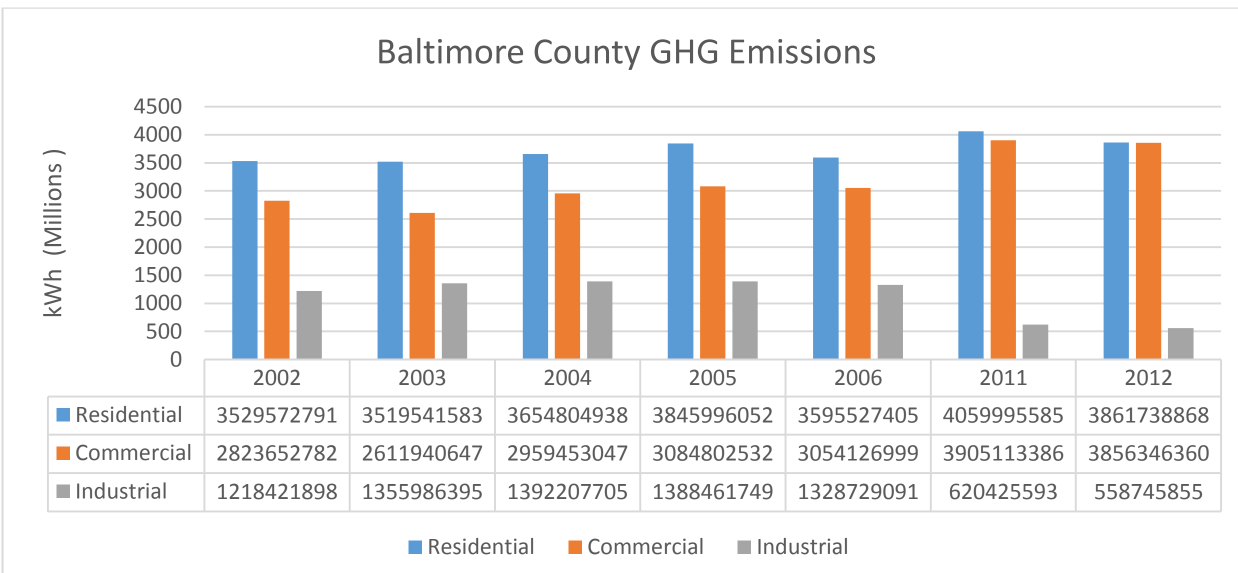
5.2 Energy

Baltimore County is one of the larger counties within the state, covering 682 square miles. Being adjacent to the city and in close proximity to a major port allows for many industries to be located in Baltimore County. There are 2,642 industrial buildings along with 321,000 residential households and 18,391 commercial buildings in Baltimore County according to the U.S. Bureau of Economic Analysis and the Baltimore County Department of Planning. The number of commercial structures in the county outnumbers the number of industrial structures significantly. Specific heavy industries include 1 steel mill and 1 steel products manufacturing facility, 1 paper company, 2 electric companies, and a small number of lube and sealant manufacturers. While industrial operations are few in number in proportion to the residential and commercial structures representing only 12.38% of the entire state, industrial structures require extremely large amounts of electricity to be functional (Brady, 2008). Graphical analysis of energy data show different 5 year trends when comparing units of MMt eCO_2 to kWh due to varying data sources and calculations, however Emphasis will be given to the MMt eCO_2 (Figures 5 & 6) In 2011 and 2012 the industrial sectors required 620,425,593kWh and 558,745,855kWh respectively representing a gradual decline in energy use from 2011 to 2012; and a 58.0 % reduction from the 2006 baseline data energy demand which was derived to be 1,328,729,091kWh. (Figure 6) When comparing the respective yearly values in units of MMt eCO2 (Figure 5) there remains a downward trend from 3,195,697 to 2,288,080 Mt eCO2 which is a 64% reduction from the 2006 baseline values. However it is unclear if the reduction is due to a rebound effect or a change in behavioral habits. Further in depth analysis of behavioral habits could also reveal that reductions in energy use were due to great recession started in 2008.



	2002	2003	2004	2005	2006	2011	2012
Residential	3268817	3392356	3413804	3530181	3195697	2405547	2288080
Commercial	2296482	2235746	2415026	2477361	2331496	2313780	2284885
Industrial	926726	989726	1012129	1018325	956473	367602	331057

Figure 5 Baltimore County GHG Emissions 2002-2006, 2011-2012



	2002	2003	2004	2005	2006	2011	2012
Residential	3529572791	3519541583	3654804938	3845996052	3595527405	4059995585	3861738868
Commercial	2823652782	2611940647	2959453047	3084802532	3054126999	3905113386	3856346360
Industrial	1218421898	1355986395	1392207705	1388461749	1328729091	620425593	558745855

Figure 6 Baltimore County GHG Emissions 2002-2006, 2011-2012

The number of commercial buildings for Baltimore County was reported to be 18,391 according to the Baltimore County Department of Planning. Proportionally it is 12.8% of the 143,680 commercial structures for the state of Maryland with an energy demand of

62,805,130,181kWh and 61,310,467,727 kWh in 2011 and 2012 respectively. The commercial sector had the second highest electricity demand compared to the industrial and residential sectors. For 2011 and 2012, the amount of electricity consumed equated to 2,313,779 Mt eCO_2 and 2,284,885 Mt eCO_2 respectively. The calculated values represent a gradual decline from the 2006 base line calculation of 2,331,496 Mt eCO_2. Specifically for the year 2012, a 2.0 % decline or 46,661 Mt eCO_2 reduction. Per kWh from 2011 to 2012 graphically there is a gradual decline but an overall increase of 21% for the commercial sector. (Figure 5 and Figure 6) Financial, retail, construction, education, public administration, and thousands of other buildings were categorized as commercial. While there is no exact number of commercial buildings for the county, the estimated scale requires a substantive amount of electricity. The findings are also aligned with 2011 statewide energy use. (Figure 7)

The residential and commercial demand for energy is close in numbers. There are 321,000 residences within Baltimore County, which is 14.88% of the state of Maryland's 2,157,717 residences. The Baltimore County residential demand for energy was 4,059,995,585kWh for 2011 and 3,861,738,868kWh for 2012. A substantial decline in energy use was observed based on calculations from the 2006 baseline MMt eCO_2. The 28 % decline equated to 117,467 Mt eCO_2 of fewer emissions. Analysis based on calculations in kWh units indicate a 5% decline from 2011 to 2012 and an overall 7 % increase from the 2006 baseline in kWh. These trends are represented by Mt eCO_2 and kWh graphically in Figures 5 & 6. The further north you travel into the county, the land becomes agriculture and forest. Forests and farms for all uses are more to the north while commercial areas are focused more to the southern areas along the city's edge and closer to the waterways. It should be noted that the numbers of houses and communities will only continue to grow in the future due to population pressures, if the status quo remains in accordance with current trends.

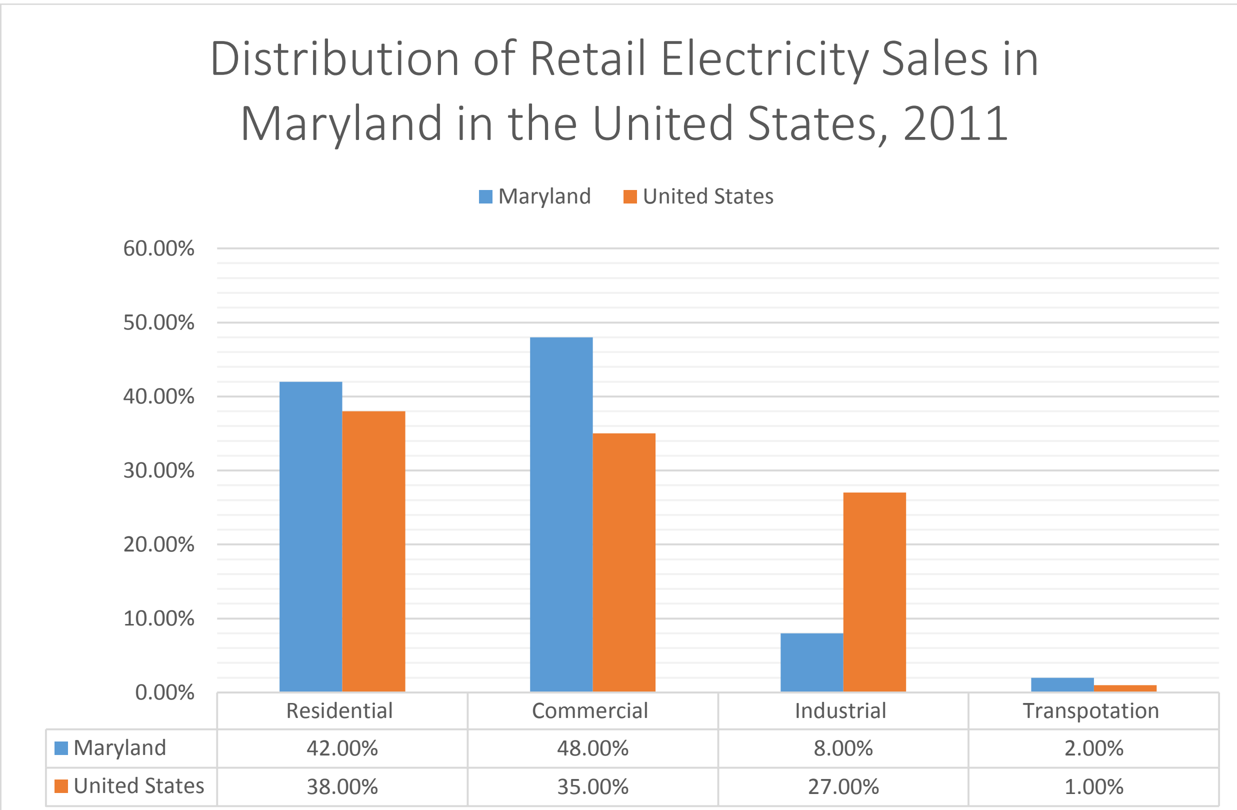
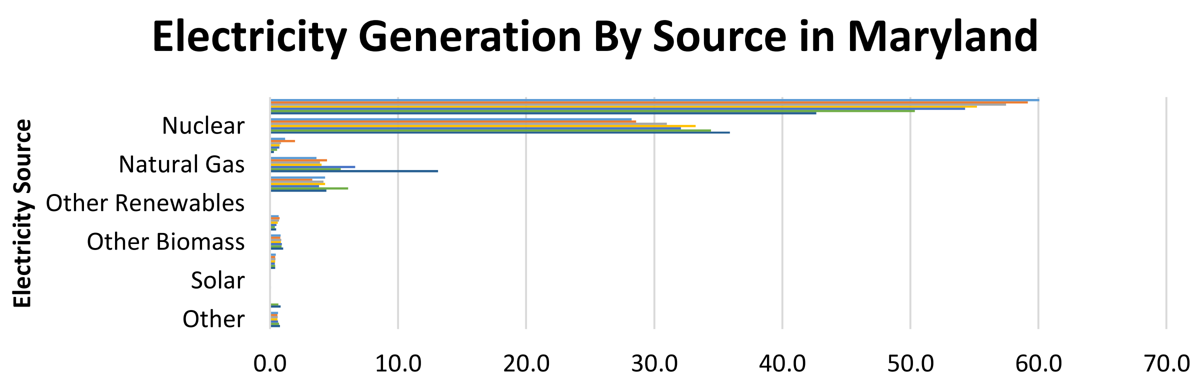


Figure 7: Graphical Distribution of Maryland Electricity Sales Data Source: (Resources, 2013)

The State of Maryland's website was utilized to supply energy data. The total electricity generated was reported with the individual fuels sources as well; sources such as coal, natural gas, oil, steam, propane, and many others. Of these sources, coal accounts for the majority of the electricity to the county. Propane, kerosene and diesel fuels are some of the smaller contributors but are still counted. The steam energy source was excluded from the emissions of

CO_2 because it does not generate carbon. There are low amounts of renewable energy sources being used in comparison to fossil fuels and other non-renewable sources. Additionally, albeit sources show minuscule to zero emission of CO_2 by nuclear energy production, it should be mentioned that the proportion of energy from nuclear sources have increased steadily from 2006 to 2012 for the state of Maryland. The reporting is relevant because the increase represents a decrease of energy production via fossil fuels (Figure 8).



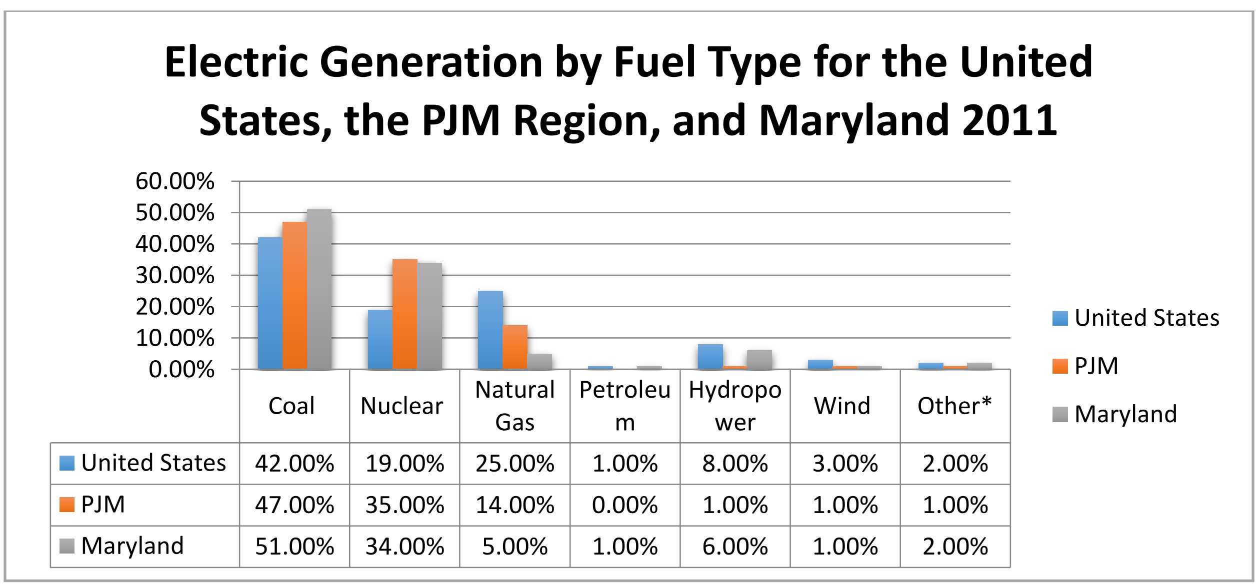
	Other	Wind	Solar	Wood	Other Biomass	Other Gases	Other Renewables	Hydroelectric	Natural Gas	Petroleum	Nuclear	Coal
2006 (%)	0.6	0.0	0.0	0.4	0.8	0.7	0.0	4.3	3.6	1.2	28.3	60.1
2007 (%)	0.6	0.0	0.0	0.4	0.8	0.8	0.0	3.3	4.5	2.0	28.6	59.2
2008 (%)	0.6	0.0	0.0	0.4	0.9	0.7	0.0	4.2	3.9	0.9	31.0	57.5
2009 (%)	0.6	0.0	0.0	0.4	0.9	0.6	0.0	4.3	4.0	0.8	33.2	55.2
2010 (%)	0.6	0.0	0.0	0.4	0.9	0.5	0.0	3.8	6.6	0.7	32.1	54.3
2011 (%)	0.7	0.6	0.0	0.4	0.9	0.4	0.0	6.1	5.5	0.5	34.4	50.4
2012 (%)	0.8	0.8	0.1	0.4	1.0	0.5	0.0	4.4	13.1	0.3	35.9	42.7

2006 (%) 2007 (%) 2008 (%) 2009 (%) 2010 (%) 2011 (%) 2012 (%)

Figure 8 Electricity Generation by Source in Maryland 2006 to 2012 Data Source: (Ahearn, 2013)

Multiple efforts were made to attain nuclear data specific to Baltimore County. The office of State Senator Joan Carter Conway, Chair of the Maryland General Assembly Committee on Education, Health, and Environmental Affairs was not able to produce primary source data for percentages of electricity consumed from nuclear reactors. Additionally, David Young from CENG was unable to report any data for the study at the present time. There was success when reaching out to Susan Grey of the Maryland Power Plant Research Program.

Lastly, with regards to nuclear energy, a communication spokesperson indicated regional level data as oppose to local data (Baltimore County) are collected for nuclear energy production. According to the BGE website the 2011 PJM Regional Data adjusted for BGE Renewable Energy Credit purchases reported 34.93% of electricity from nuclear energy production. It should be noted that the utilization of nuclear technology in 2011 was reported to abate 12,190,000 metric tons of CO_2 from being released into the atmosphere, according to the Nuclear Energy Institute. Electricity generation by nuclear production is almost double that of the United States for the PJM and the state of Maryland (Figure 9).



	Coal	Nuclear	Natural Gas	Petroleum	Hydropower	Wind	Other*
United States	42.00%	19.00%	25.00%	1.00%	8.00%	3.00%	2.00%
PJM	47.00%	35.00%	14.00%	0.00%	1.00%	1.00%	1.00%
Maryland	51.00%	34.00%	5.00%	1.00%	6.00%	1.00%	2.00%

Figure 9 U.S. PJM Electricity Fuel Type Data Source: (Resources, 2013)

Most of the data collected came from the Maryland State government website, but other information was found on the websites Excelon and Energy Information Administration (EIA). These two, among other organizations monitor all energy brought to this region of the country. They track fuel type by source and endpoint. The data obtained were hard to come by for the 2012 year. The records keeping track of the energy have data up to 2011. Not many of the sources have collaborated the 2012 or 2013 records yet. The fuels are tracked at different paces; meaning records for coal might exist but nuclear has not yet been collected. This makes it difficult to precisely sum up the total electricity use for the 2012 and 2013 years. These data are necessary in figuring out carbon emissions.

Maryland ranks 40th in the United States with energy consumption (EIA U. S., 2011). The biggest sector consuming the energy is transportation followed by the commercial sector. The numbers should be high, especially when considering the businesses that need a lot of energy to maintain day to day operations such as; restaurants and the refrigerators that run high at all times, or big office buildings that maintain hundreds of employees.

The largest fuel sources for the state are coal, gasoline, and natural gas (EIA U. S., 2011). These fuels have the most output to input ratio. There is high dependency on relatively cheap and accessible fossil fuels. These sources will eventually run out and then renewable fuels will be sought after. Renewable fuels are used today, but at much lower rates than their counterparts. Nuclear, wind, etc. are, at the time, more expensive and produce less, but are cleaner sources (Ahmad & Tahar, 2013).

5.3 Waste

The eCO_2 data for 2012 represent a 150,049 metric ton emission by Baltimore County Community, showing a 10.05% decrease in GHG emissions since the 2006 baseline. Due to the lack of having an eCO_2 emissions calculator, extrapolation of a divisor could have introduced experimental error into our calculations. Subsequent inventories would benefit from detailed solid waste trends for each year starting from the baseline year. This allows the study of socio-economic factors that could contribute to greenhouse gas emissions and reductions.

Solid waste generated in Baltimore County is sent to three separate drop-off sites; these include Eastern Sanitary Landfill Solid Waste Management Facility, Baltimore County Resource Recovery Facility, and the Western Acceptance Facility (Works, Trash and Recycling Drop of Facilities, 2013). Waste sent to landfills contributes to increased amounts of greenhouse gases in the atmosphere through the process of decomposition. As waste decomposes within landfills, methane gas is emitted. Methane gas has only a 12 -year lifetime in the atmosphere, but it traps radiation 21 times greater than CO_2 over a 100- year period, therefore achieving Global Warming Potential of 21 (IPCC, 2013). There are landfills and drop-off facilities within Baltimore County that are inactive that may still be emitting methane, but information could not be found for these sources.

The reduction seen from 2006 to 2012 based on this inventory's calculations can be attributed to the Baltimore County Ten Year Solid Waste Management Plan. This uses a hierarchal categorization system to rank management schemes for the entire county in this order: waste reduction, recycling, resource recovery, and landfilling (Works, Ten Year Solid

Waste Management Plan, 2014). Enacted in 2008, the management plan continually monitors and updates facilities and landfills, as well as proposes updated schemes to reduce landfill waste.

Figure 10 illustrates the amount of waste produced by Baltimore County in terms of equivalent carbon dioxide from 2002 to 2006 with the addition of 2012. Between 2002 and 2006, the numbers fluctuate between 177,180 metric tons to 159,402 metric tons. Gaps in our data could hide potential inconsistencies but the most recent data reflects an overall decrease in the amount of equivalent carbon dioxide produced.

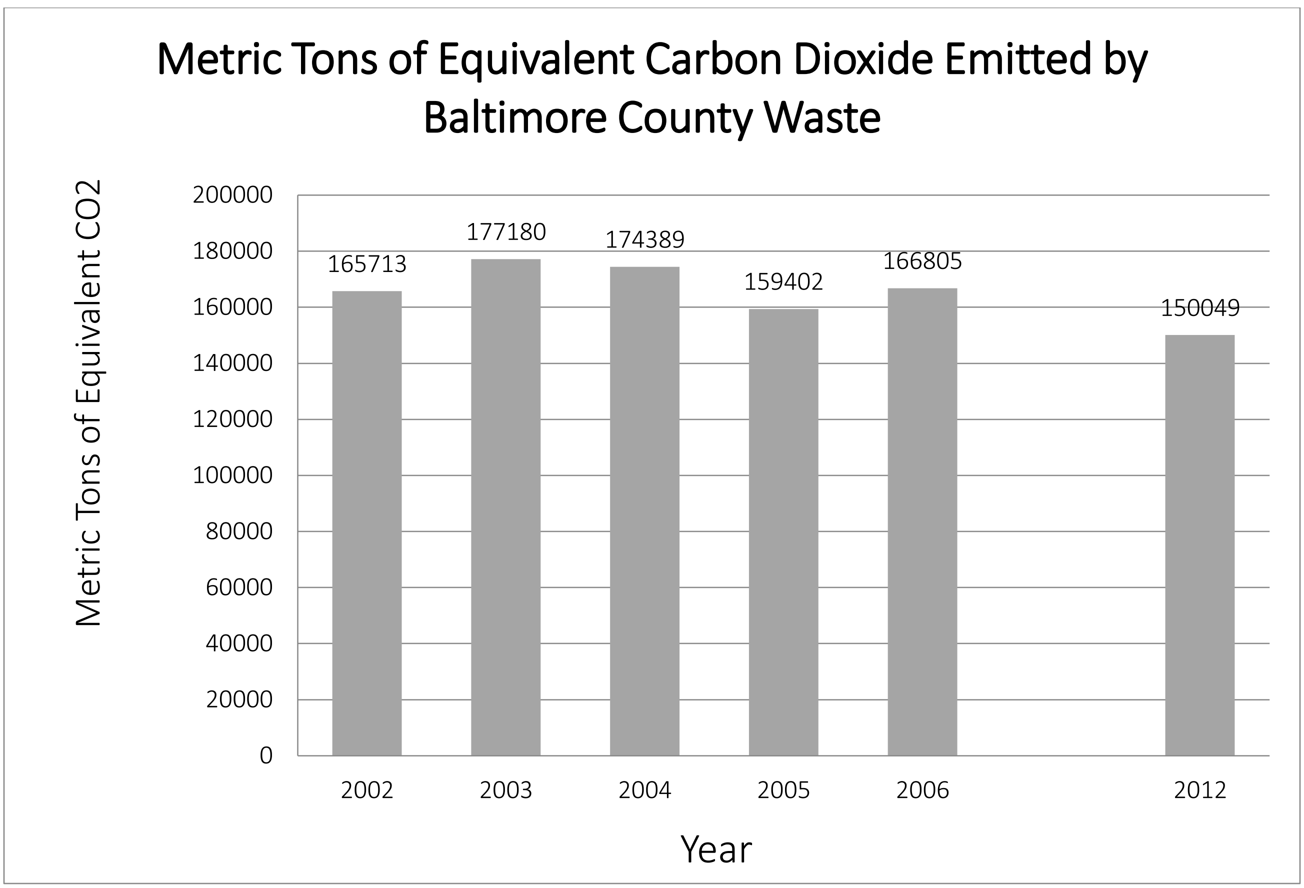


Figure 10 Metric Tons of Equivalent CO2 emitted by Baltimore County Waste Sector from 2002-2006 with 2012 included.

6. Recommendations

6.1 Transportation

The 2013 Maryland Mobility Report focuses on Transit Oriented Development (TOD) as a solution to reducing the number of vehicles on the road at any given time. The report supports what it calls "smart growth" in order to reduce the stress on the roads. (TOD) is to promote efficient land use by building communities around transit centers in order to promote alternative transportation. These developments are to encourage employees and community residents to walk, bike or take transit to their destinations, reducing the CO_2 output from riding individual motor vehicles. Several transit projects are already being incorporated into communities as the Maryland Department of Transportation (MDOT) and the MTA are developing two major light rail designs, one of which will extend 14.1 miles from Baltimore County into Baltimore City. Developing high occupancy vehicle (HOV) lanes has also been successful in promoting more riders per vehicle, and bus or van use in the area.

"Smart Growth" initiatives which aim at constructing different development and conservation strategies, will help to preserve and protect the natural environment from further damage (Transportation, 2011). It also aims at making the communities more sustainable, by building public transportation, sidewalks, and bike paths in order to decrease emissions, as well as building schools, stores, residences, and businesses closer together in order to reduce the need for driving.

Smart Growth also plans to release reports that show improvements in the city based upon the methods implemented in order to reduce emissions. These reports will also show where else the city is able to improve. The program intends to use such reports to not only influence future policies, but also to "bring together diverse interests and encourage better growth and development". Currently, Baltimore County is following the plans outlined in the Maryland Climate Action Plan which intends to reduce emissions through various practices (Transportation, 2011). Some of these practices including improving vehicle technology in order to improve fuel economy, expand public transportation plans including Maryland Rail Commuter Service (MARC), improved bicycle and pedestrian access to transit, along with commute alternative incentive programs funded by the state.

Park and ride is a system that not only lessens the amount of traffic in the city, but also reduces the amount of greenhouse gases emitted as there are fewer cars on the road. Commuters, instead of driving to their destinations, will park their cars and ride into the city using public transportation. Public transportation not only alleviates the emissions from all the cars on the road that would be if each passenger were to drive, but also alleviates the congestion caused by traffic in urban areas.

However, that is not all that is suggested to do in order to reduce greenhouse gas emissions. According to the Environmental Protection Agency (EPA), fuel switching should be the priority if one is to use a car or bus. One is encouraged not only to use public transportation, but also to use buses that are “fueled by compressed natural gas rather than gasoline or diesel”, or hybrid buses, which are becoming popular in major metropolitan areas. Another similar method that can reduce the number of cars on the road is kiss-and-ride, where people are driven to a certain destination or to a public transportation site and are dropped off so that they can get to wherever they are going, either by foot or by public transportation.

A city in which everything is accessible by foot or bike would decrease the emissions produced from transportation methods that rely on petroleum, and would be a revolutionary change altogether. The community would be more sustainable, and could quite possibly allow its citizens to live without having to own or use a car. If they do own a vehicle, then they would very rarely have to use it.

6.2 Energy: Residential, Commercial, and Industrial

Recent technological advances, combined with effective marketing, have changed the ethos regarding economic development and sustainability practices. The technology transfers have created a new energy market allotting consumers competitive pricing with more options to invest in energy efficient upgrades for residential, commercial, and industrial buildings. (Casey, 2013) The term used to describe the aforementioned concept is “Smart Building”. According to the website whatis.techtarget.com, “Smart Building” is defined as a home or building, usually a new one, that is equipped with special structured wiring to enable occupants to remotely control or program an array of automated home electronic devices by entering a single command. (Rouse & Wigmore, 2005) Some feature associated with residential, commercial, and industrial smart buildings are motion-sensitive lighting, which ensures that lights are shut off in unused rooms automatically rather than leaving it up to individuals to remember. Another feature is advanced thermostats which can quickly and accurately adjust to ongoing variations within a building. These sensors adjust to the body warmth generated by higher occupancy at different times of the day, as well as adjusting to warmth generated by appliances and equipment. The aforementioned component in terms of scale can have a significant impact on the bottom line for commercial and industrial buildings. Additionally, "Smart Meters" (home electric and temperature meters) empower human decision-making in residential settings by providing more information about energy consumption in a detailed format with higher frequency than monthly meter readings. This feature enables individuals to decide when to run major appliances or equipment in order to take the best advantage of off-peak rates. (Casey, 2013) Another technological component of sustainable energy consumption is electric lighting, which is currently dominated by decades-old incandescent and fluorescent sources, is being taken over by white light emitting diodes, which are solid state devices with much greater energy savings. Replacement of current inefficient lighting by these LEDs will result in reduction of global carbon dioxide emissions. (Kavehrad, 2010)

New business platforms and individual consumer adaptations to sustainable practices not only promotes good stewardship of the environment, it is fiscally advantageous. Individual, local, state, and regional curtailing of energy demand can have a global impact. From academic journals to online blogs and news publication, sustainable activities are becoming common knowledge and incorporated in to day to day activities in the commercial, residential, and industrial sectors of energy consumption. One can only assume this has contributed to the downward trend of energy demand for Baltimore County. It is strongly recommended that the sectors build on and report best practices to contribute to the empirical evidence as well as become a national model to follow.

6.3 Waste Reduction and Prevention

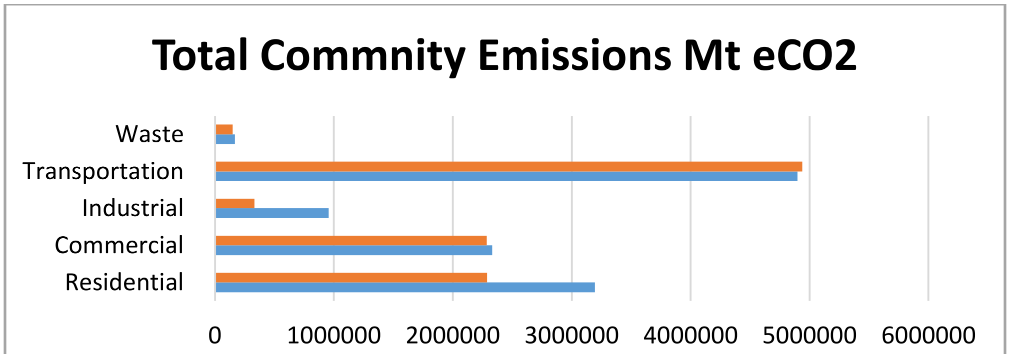
The EPA currently utilizes a hierarchy scheme for solid waste management that categorizes solid waste management strategies from most preferred to least preferred methods of management (EPA, Non-Hazardous Waste Management Hierarchy, 2013) (Figure 11). This incorporates reduction and reuse, recycling and composting, and energy recovery as the most effective and preferred methods of solid waste management reigning over landfilling.

Figure 11 Solid Waste Management Hierarchy

Waste management practices differ with changing social and economic contexts, therefore multiple strategies have to be evaluated for each country, state and county (Xudong, Height, Yong, & Fuhita, 2010). Barriers to management involve engaging the public to participate in reduction of solid waste within their homes. Rising income levels raise the rate of consumption with developing and developed countries, unfortunately creating an increase in solid waste sent to landfills (O'Connel, 2011). The task then relies heavily on consumers within residential homes. 4.62 pounds of solid waste per person are generated in one day within the United States as compare to 1.62 pounds of waste per person in the United Kingdom. Switching from w (O'Connel, 2011) waste treatment and disposal to environmentally efficient alternatives becomes necessary.

Reducing the amount of waste sent to landfills minimizes major anthropogenic sources of methane. Waste minimization can be achieved through a change in consumption trends within in the home, including purchasing only necessities, and reducing the amount of wasted food products and materials within each household. Recycling and composting are further trends to reduce waste sent to landfills. Aerobic composting incorporates human agitation to compost in order to achieve aeration. As waste decomposes it will emit carbon dioxide, which is 21 times less potent as a greenhouse gas than methane, in contrast to anaerobic composting that emits methane (Wadker, 2013)

7. Significance and Information for Subsequent Inventories



	Residential	Commercial	Industrial	Transportation	Waste
2012	2288080	2284885	331056	4939272	150049
2006	3195697	2331496	956473	4897796	166805

Figure 12Total Community Emissions Comparison 2006 and 2012

Data yields for the 2012 Greenhouse Gas Inventory show an overall 14% decrease in GHG emissions for the Baltimore County Community over a 6-year period. The calculated value for 2006 was 11,548,267 Mt eCO_2 whereas the calculated value for 2012 is approximately 9,993,342 Mt eCO_2. Changes in methodology for the 2012 GHG inventory are attributed to the variation reported in the results because of the extrapolation data used due to the lack of available eCO_2 calculators present. For example, the eCO_2 in metric tons reported in 2006 were used to calculate kilo watt hours within the current model's framework. Specifically the reported 3,195,695 Mt eCO_2 equated to 3,595,527,405 kWh in the 2006 inventory whereas the present inventory equated the value to be 5,393,581,435 kWh. Another factor contributing to the variation is attributed to the estimations and conversions from trillions of BTU to MMt to kWh. It should be noted that application of the present model to previous years reported by the Pat Brady still suggest a downward trend however variation and data quality between the models does somewhat jeopardize the integrity of the investigation. While the calculations suggest an overall downward trend, it should be further noted that identical percent county to state ratios were used for calculations of years 2006, 2011, and 2012 in the current assessment which may also contribute to the experimental difference between the two inventories. As noted in the Pat Brady 2006 study, data sources and assumption can heavily influence the outcome of greenhouse gas inventories. 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. Data are often aggregated at national and state level not at city of county levels. While it is common practice for organizations to track their costs for energy use in buildings, kWhs are not tracked. (Brady, 2008)

Moving forward, in subsequent inventories, including the current, it would be useful to identify if the downward trend is due to a reduction in consumption or to more efficient technologies that are able to abate increased energy demand/usage. This would paint a clear picture of the need for targeted conservation/messaging to change behavioral habits with regards to energy consumption.

Additional data sources should be included to develop a more accurate greenhouse gas inventory in the future, such as emissions from marinas, air travel, and railroads. Lack of available data prevented the inclusion of these sources within the 2012 GHG inventory. Additionally, data for vehicle miles traveled by mass transit in the Baltimore County Community must be extrapolated to reflect other modes of transportation in Baltimore County and to determine the number of individuals utilizing public transportation. Further research investing in offsets, such as forested areas, is also important in representing Community totals of GHG emissions.

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