County of Albemarle, VA
Emissions Baseline Report

A summary of greenhouse gas and criteria air pollutant emissions for the County of Albemarle, VA for the year 2000




Department of General Services
County of Albemarle
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EXECUTIVE SUMMARY

Scientists from the U.S. Climate Change Science Program and the Intergovernmental Panel on Climate Change (IPCC) both state that "there is robust scientific evidence that human-induced climate change is occurring." Over the last one hundred years, there has been an increase of ~0.6°C in average global surface temperatures, an increase of ~20cm in sea level and an increase of ~2% in global precipitation over land. As a result of greenhouse gases already emitted, the U.S. Climate Change Program's 2007 report predicts that temperature increases will likely increase globally by another 1°C up to 4°C over the next 100 years. Scientists from George Mason University and the Center for Ocean-Land-Atmosphere Studies in Maryland estimate that Virginia in particular can expect to see an increase in its temperature by 3.1°C. To mitigate further change, many institutions have urged reductions in greenhouse gas emissions.

The Cool Counties Climate Stabilization Initiative is a commitment made by 12 pioneering U.S. counties to reduce their contributions to climate change and help their communities become resilient to consequent changes. On December 5, 2007 the Albemarle County Board of Supervisors joined these counties by adopting the *U.S. Cool Counties Climate Stabilization Declaration*, pledging to reduce emissions County-wide by 80% by 2050.

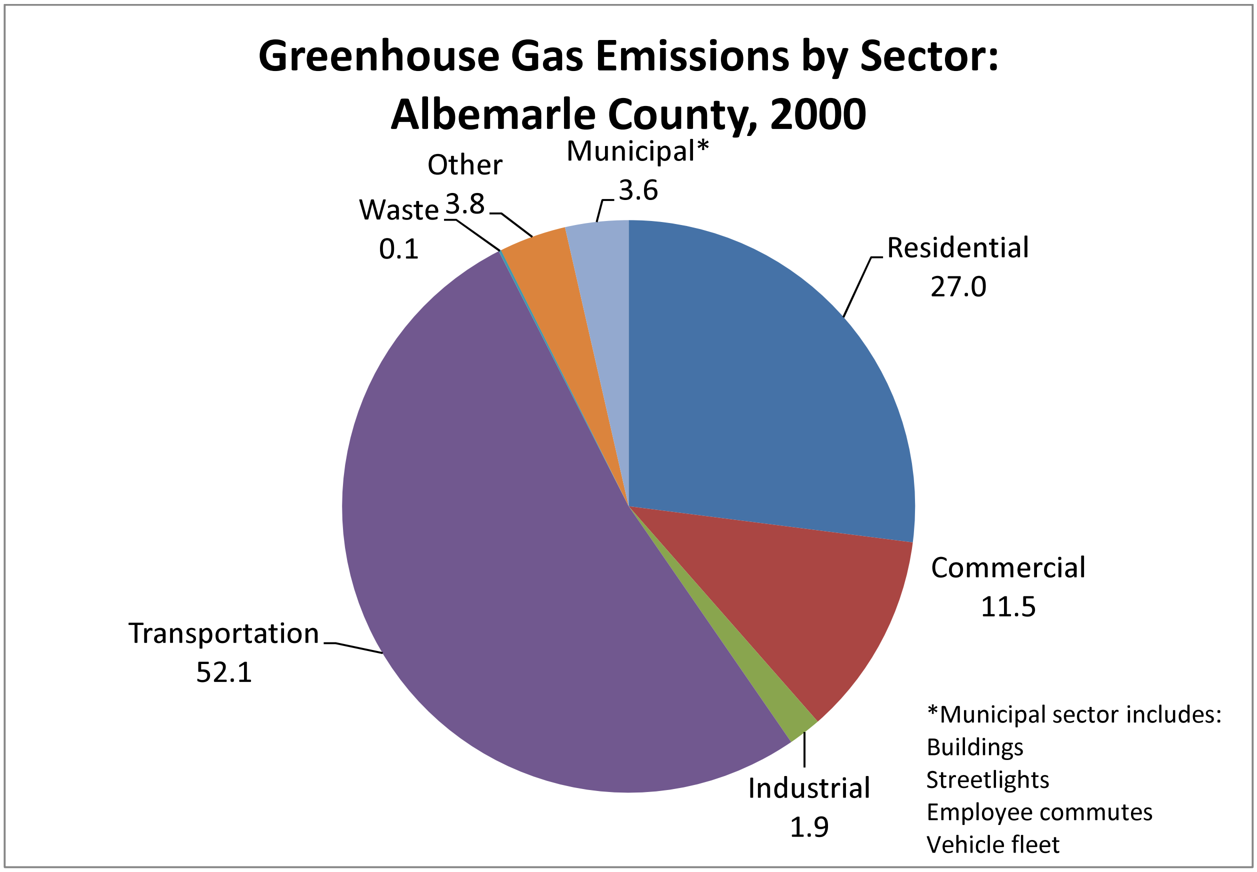
The County is following the International Council for Local Environmental Initiatives' (ICLEI) Five Milestone approach to addressing climate change. This baseline inventory is the first of the Milestones. The Five Milestones include, in summary: 1) Conduct a baseline emissions inventory and forecast; 2) Adopt an emissions reduction target for the forecast year; 3) Develop a Local Action Plan; 4) Implement policies and measures in Local Action Plan; and 5) Monitor and verify results.

The Kyoto Protocol calls for a reduction of emissions by developed countries by 5% relative to a baseline year of 1990. However, due to difficulty in accessing accurate records for community and government utility use for the year 1990, the County is using a baseline year of 2000. This is consistent with the City of Charlottesville's, University of Virginia's, and the State of Virginia's baselines, and therefore will aid any future collaboration on emission reduction measures between the organizations.

Baseline Data Summary:

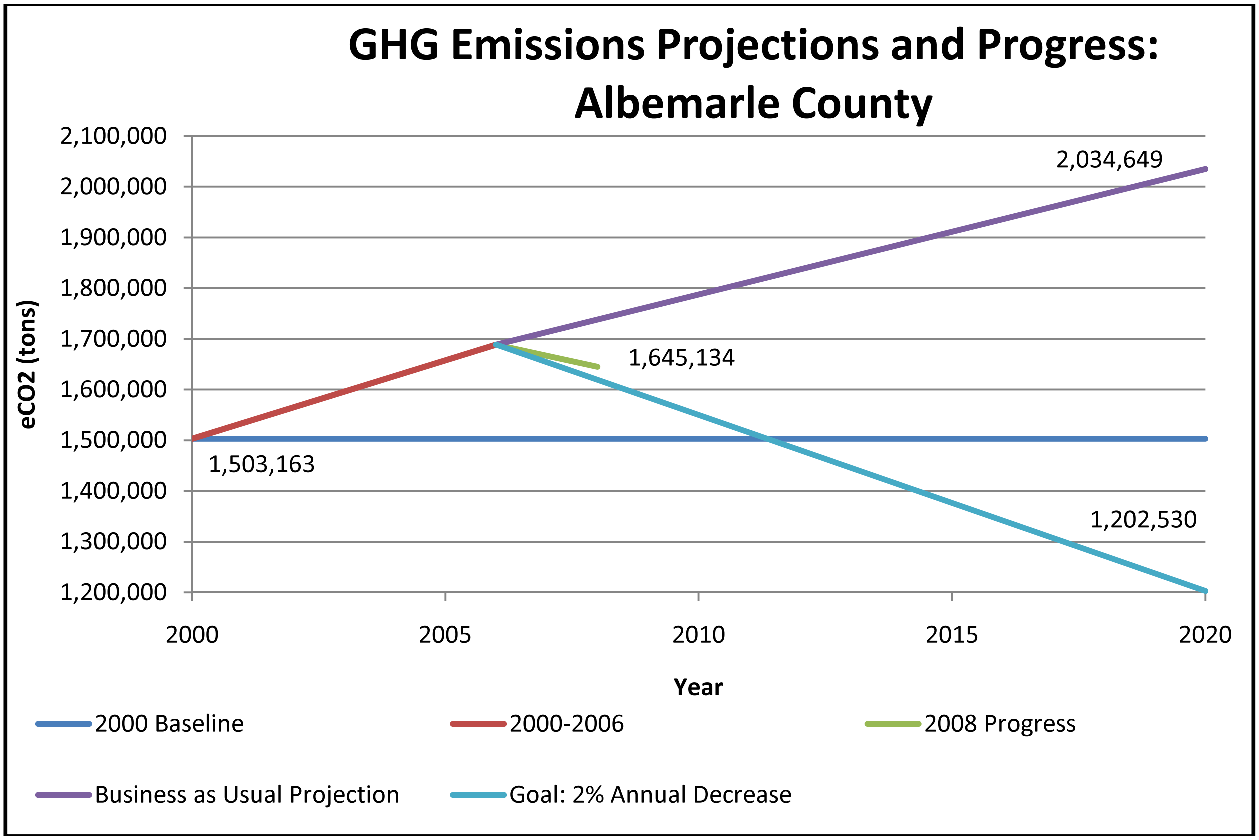
Year	Energy Use Million British Thermal Units (MMBtu)	Total eCO_2 Emissions (Tons)
2000	13,132,671	1,503,163
2006	14,923,434	1,688,426
2020 Projection	18,424,667	2,034,650

The baseline data was analyzed using the Clean Air and Climate Protection (CACP) software developed by ICLEI. According to the software, the County emitted a total of metric tons of equivalent carbon dioxide (eCO_2) in the year 2000. Specific breakdowns across sectors (transportation, commercial, residential, etc.) are presented below. In 2000, the 84,186 residents of the County each emitted approximately 17.9 tons of eCO_2. In 2006, total emissions increased to 1,688,426 eCO_2 tons while the population grew to 85,752 people, so per capita eCO_2 emissions were 19.7 tons. The following graph breaks down the relative contributions to baseline emissions by sector:



The CACP software allows for "forecast" projections up to the year 2020 based on a "business-as-usual" scenario. This scenario assumes that governments, companies or individuals will not take any actions specifically directed at limiting greenhouse gas emissions. The projected emissions for 2020 in this "business as usual" scenario are 2,034,650 eCO_2 tons (See Figure 10 for more detailed information).

By adopting the *U.S. Cool Counties Climate Stabilization Declaration*, the County pledged to reduce emissions by 80% by the year 2050, or an average of 2% per year beginning in 2010. Thus, by the year 2020 the County must reduce emissions by 20% from its baseline emissions, or to 1,202,530 tons of eCO_2 (see figure on next page) in order to meet its target.



The next major step following the baseline emissions analysis is to engage in a Local Climate Action Planning Process. Members of the Albemarle County Board of Supervisors, the Charlottesville City Council, and officials from the University of Virginia have all expressed a keen interest in collaborating on such a process. In January 2009, the Albemarle County Board of Supervisors and the Charlottesville City Council unanimously passed resolutions in support of the County, City and University working together to address energy efficiency and climate change. Environmental staff members from the three organizations are currently developing plans to establish a Steering Committee and a set of Focus Groups that will launch the planning process. It is anticipated that outcomes from this process will shape public policies and programs as we individually and collectively look to reduce our contribution to the world's greenhouse gas emissions. The Steering Committee will ultimately issue a report outlining strategies that are particular to each entity, as well as those that present shared opportunities. In the end, each participating entity will have to determine what strategies are appropriate for implementation and how that implementation will take place. However, the expectation is that in those areas where cooperation and synergy are needed, Albemarle, Charlottesville, and UVa will share an approach.

PART 1. CLIMATE CHANGE

Overview

Over the last one hundred years, there has been an increase of ~0.6°C in average global surface temperatures, an increase of ~20cm in sea level and an increase of ~2% in global precipitation over land. These changes represent a dramatic departure from natural weather fluctuations that occur every few millennia. Scientists from the U.S. Climate Change Science Program and the Intergovernmental Panel on Climate Change (IPCC) both confirm that these changes are not natural and, in fact, "there is robust scientific evidence that [this is] human-induced climate change." Furthermore, these global temperature and precipitation trends have also been observed in the United States.

Causes

Climate change, also known as "global warming", results from an over-amplification of the greenhouse effect. Solar radiation that hits the Earth is equaled in magnitude with the amount of energy the Earth emits towards space. The greenhouse effect, a naturally occurring process, occurs when greenhouse gases (carbon dioxide, methane, water vapor, etc.) absorb and re-emit some of the Earth's outgoing infrared radiation back towards it (Figure 1). Water vapor is actually the most abundant of these gases, and is therefore the most important. Note: Because almost 99% of water vapor originates naturally and cannot be controlled through greenhouse gas reduction measures, it is not included in Table 1 below or assessed in this report.

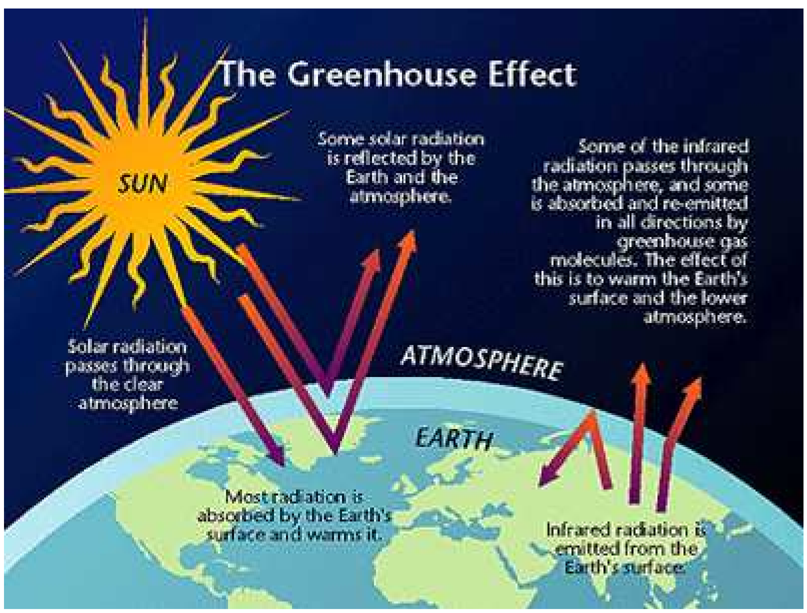


Figure 1: The naturally-occurring greenhouse effect is necessary for life. Historically, it has increased the average global surface temperature from 0°F to a more pleasant 57°F.

Historically, the greenhouse effect has made conditions much more bearable on Earth by increasing the average global surface temperature from 0°F to a more pleasant 57°F. Human activities in the last 150 years, however, have greatly amplified the greenhouse effect by increasing the concentration of greenhouse gases in the atmosphere. Some of these gases occur naturally (e.g. carbon dioxide, methane, water vapor), while others are exclusively man-made (e.g. hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride). Table 1 lists some well-known greenhouse gases and their sources. Fossil fuel burning and land use changes (deforestation and pollution from industrial sources, in particular) have increased the volume of greenhouse gases in the air.

While all greenhouse gases re-emit energy back towards the Earth, some are much more efficient in doing so than others. The global warming potential (GWP) is a measure of this efficiency. It is a ratio of the warming that would result from one kilogram per greenhouse gas relative to one kilogram of carbon dioxide (kg CO_2) over a fixed period of time. When reporting total emissions of all tracked greenhouse gases, it is standard to convert the GWPs into CO_2 equivalent units (eCO_2).

Table 1. Key greenhouse gases and their corresponding global warming potential.

Greenhouse Gas	Source	GWP
Carbon dioxide (CO_2)	Fossil fuel burning, solid waste, trees and wood products.	1
Methane (CH_4)	Landfills, coal mines, oil / natural gas operations, and agriculture.	21
Nitrous oxide (N_2O)	Fertilizers, fossil fuel burning, and waste management.	310
Hydrofluorocarbons (HFCs)	Synthetic industrial byproducts.	650-11,700
Perfluorocarbons (PFCs)	Synthetic industrial byproducts produced in the manufacturing of aluminum products.	6,500
Sulfur hexafluoride (SF_6)	Synthetic industrial byproduct.	23,900

Impacts

While the aforementioned ~0.6°C increase in average global surface temperatures over the last 100 years may seem minor, it should be noted that the temperature difference between an ice age and a warm age is only roughly 4°C. Thus, even small temperature variations on the global scale can have drastic effects overall. Some regions of Alaska have already warmed by 4°C. The Great Plains are expected to experience intensified drought cycles while the West is expected to have fewer but more intense winter precipitation events. While we know that the U.S. as a whole became warmer and wetter over the past 100 years, local effects can vary greatly by geographic region. Scientists from George Mason University and the Center for Ocean-Land-Atmosphere Studies in Maryland estimate that Virginia, for example, will experience an increase in temperature of 3.1°C along with an 11% increase in annual precipitation over the next one hundred years. Of these region-specific changes, one of the most noticeable has been the consistent decrease in Arctic sea ice as the air temperatures in the region rise.

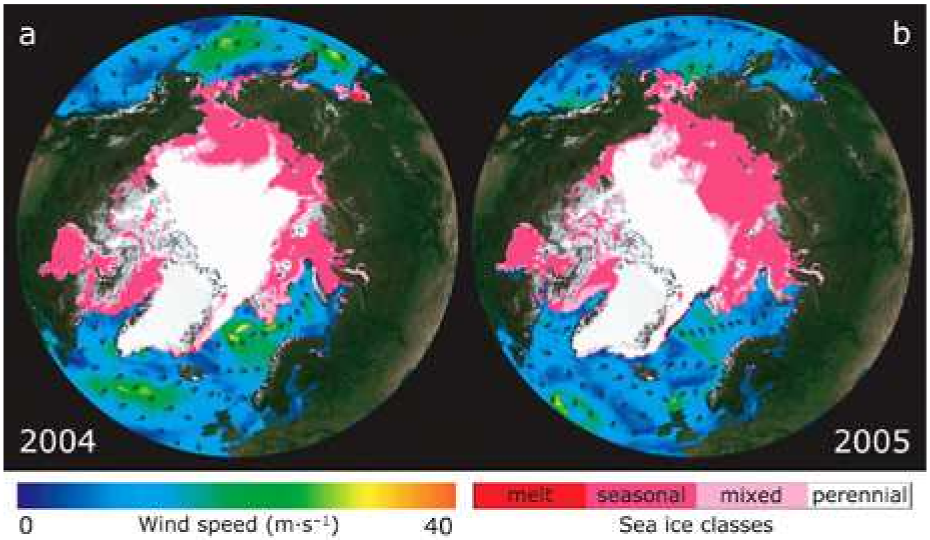


Figure 2: Photo in the News: Study Shows Arctic Ice Melting Rapidly.
Image source: http://news.nationalgeographic.com/news/2006/09/060914-arctic-ice.html

Changes in physical climate are coupled with population changes for various species of plants and animals. Some ecosystems will alter as their natural processes (e.g. nesting times, migratory routes, predator/prey relationships, etc.) acclimate to reflect new climate patterns. However, scientists estimate that large numbers of species, potentially 30-40% globally during the next 50 years, may be unable to adapt to climate change and will be lost.

A study conducted by Miller-Rushing et. al. in 2008 documents that the mean arrival dates for North American passerines at Manomet, Massachusetts occurred earlier and earlier each decade. The variations in migratory changes over time were partially explained by climate variables. In particular, short-distance passerine migrants appeared to respond to changes in temperature.

Our quality of life will also be affected by changes in agricultural productivity and increases in forest fires, insect outbreaks, severe storms, and droughts. While agricultural productivity might increase in the short-term, over the long-term, productivity will decrease as changing weather patterns exceed plants' thresholds for adaptability. The management of these effects will be very difficult due to our limited understanding of these altered ecosystems and inadequate resources. Thus, it is crucial to increase our understanding of past, present, and future processes to mitigate some of these effects.

Environment California Research & Policy Center state in their December 2007 "When It Rains, It Pours" Global Warming Report: "Scientists expect global warming to increase the frequency of heavy precipitation. Also, weather records show that storms with extreme precipitation have become more frequent over the last 60 years. Consistent with the predicted impacts of global warming, we found that storms with extreme precipitation have increased in frequency by 24 percent across the continental U.S. since 1948."

Criteria Air Pollutants

In addition to increasing global surface temperatures, the greenhouse gases listed in Table 1 also contribute to air pollution. The six most common air pollutants in the U.S. are collectively known as "criteria air pollutants." These pollutants are known to endanger public health and the environment and have therefore been the focus of Congress' regulatory attention. Table 2 lists the criteria air pollutants, their sources, and known health effects. Note: Ozone (O_3) that occurs naturally in the upper atmosphere surrounding the Earth provides a filter for the ultraviolet light emitted by the Sun. At ground level, however, ozone is harmful to living things and is an air pollutant that damages human health, vegetation, and many common materials.

Table 2. Criteria air pollutants and their corresponding sources and health hazards.

Criteria Air Pollutant	**Source**	**Health Effects**
Carbon monoxide (CO)	Burning of fossil fuels; 77% from transportation sources; wood-burning stoves, incinerators, and industrial sources.	Reduces oxygen to organs and tissues. Causes impairment of vision and dexterity.
Lead (Pb)	Lead gasoline additives, non-ferrous smelters, and battery plants.	Causes adverse reproductive effects (reduced fertility, miscarriage). Affect nervous, digestive and cardiovascular blood-forming systems.
Nitrogen oxides (NO_x)	Combustion processes from transportation vehicles and electric utility and industrial boilers.	Irritates lungs. Causes bronchitis and pneumonia.
Ozone (O_3)	Combustion processes.	Damages lung tissue and reduces lung function.
Particulate Matter (PM_{10})	Factories, power plants, cars, construction activity, fires, and natural windblown dust.	Reduces visibility. Affects breathing. Contributes to cancer and premature death.
Sulfur dioxide (SO_2)	Burning of fossil fuels, steel mills, refineries, pulp and paper mills and nonferrous smelters.	Causes visual impairment. Affects breathing.

PART 2. ADDRESSING CLIMATE CHANGE AT THE NATIONAL, STATE, AND LOCAL LEVELS

Background

Climate change, caused in part by human activities in the past 100 years, will continue into the 21st century. As a result of greenhouse gases already emitted, the U.S. Climate Change Program's 2007 report predicts that temperatures will likely increase by another 1°C, up to 4°C. The temperature patterns previously noted will thus continue to worsen. Many institutions have urged for reductions in greenhouse gas emissions in order to mitigate further changes.

The most renowned of these measures is the Kyoto Protocol, which was introduced in 1997. This measure calls for a 5% emissions reduction in developed countries relative to their 1990 levels by 2012. The Protocol was ratified by nearly 150 countries and has been in effect since 2005.

In addition to committing to the goals set by the Kyoto Protocol, many other European nations have set more stringent emission reduction targets. The United Kingdom, for example, set a "27% reduction by the year 2020" target in July 2007.

Vehicle Emissions


Smog over the United Kingdom

National Level

Although more than 150 nations have ratified the Kyoto Protocol, they only account for 32% of global emissions. The U.S. has not yet signed any binding climate protection agreement even though its population, which makes up only 4% of the global population, accounts for over 25% of worldwide emissions. The U.S. has, however, signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. Article 2 of the UNFCCC directs all nations who are signatories to develop and periodically update national inventories of anthropogenic emissions by sources and removals by sinks ("sink" in this context denotes a process or activity that results in the net removal of greenhouse gases from the atmosphere). Thus, the Environmental Protection Agency (EPA) has routinely tabulated the greenhouse gas emissions for the U.S. in their annual report entitled "Inventory of U.S. Greenhouse Gas Emissions and Sinks." According to their most recent report released in 2008, their data shows that the industrial and transportation sectors are the two largest contributors to emissions in the U.S., accounting for more than half of total emissions (Figure 3). Data from 2004 is the most current information included in their 2008 report.

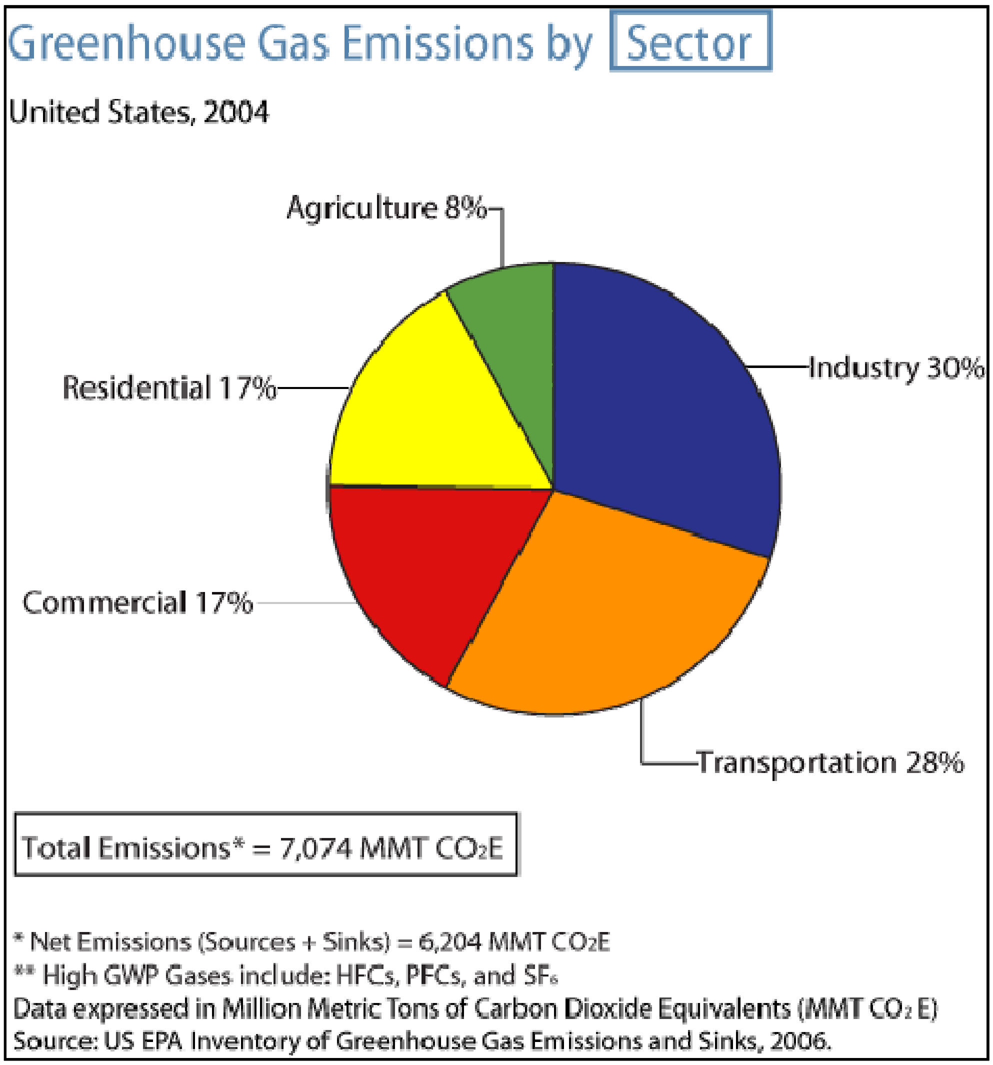


Figure 3: U.S. Greenhouse gas emissions broken down by sectors for the year 2004.
These sector-related percentage trends have been consistent over the years.

State Level

Furthering national efforts, action at the state level has been significant in recent years. According to the Pew Center on Global Climate Change, the following 36 states have either completed or are in the process of completing their climate action plans. This graph (Figure 4) was updated by the Pew Center as recently as January 12, 2009.

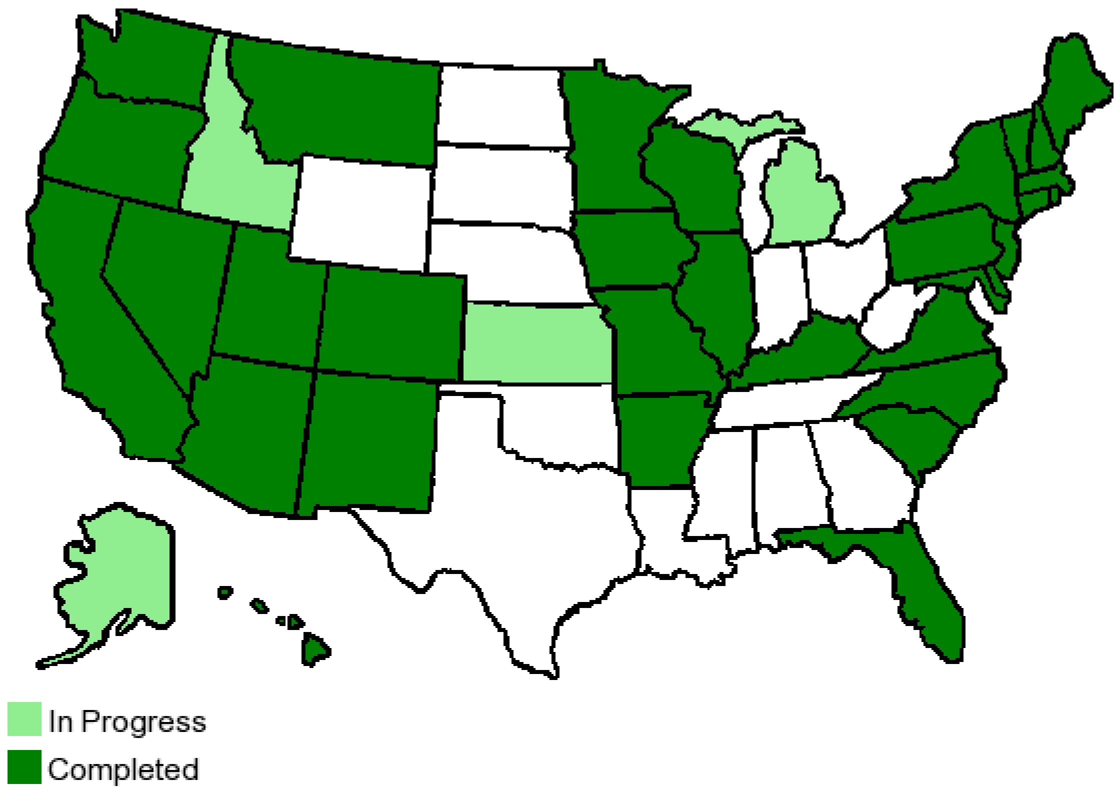


Figure 4: States with climate action plans. Source: Pew Center on Global Climate Change

Of these states, Virginia is one of roughly 20 that have also set greenhouse gas emission reduction targets. In 2007 Governor Tim Kaine's first comprehensive energy plan set a goal to reduce Virginia's emissions by 30% by the year 2025. The Governor appointed a Commission on Climate Change to ensure the state's target is met. The Commission's first assignment was to inventory all state actions to assess the status of their emissions. The Commission released the final state greenhouse gas inventory report at the end of 2008 (Figure 5).

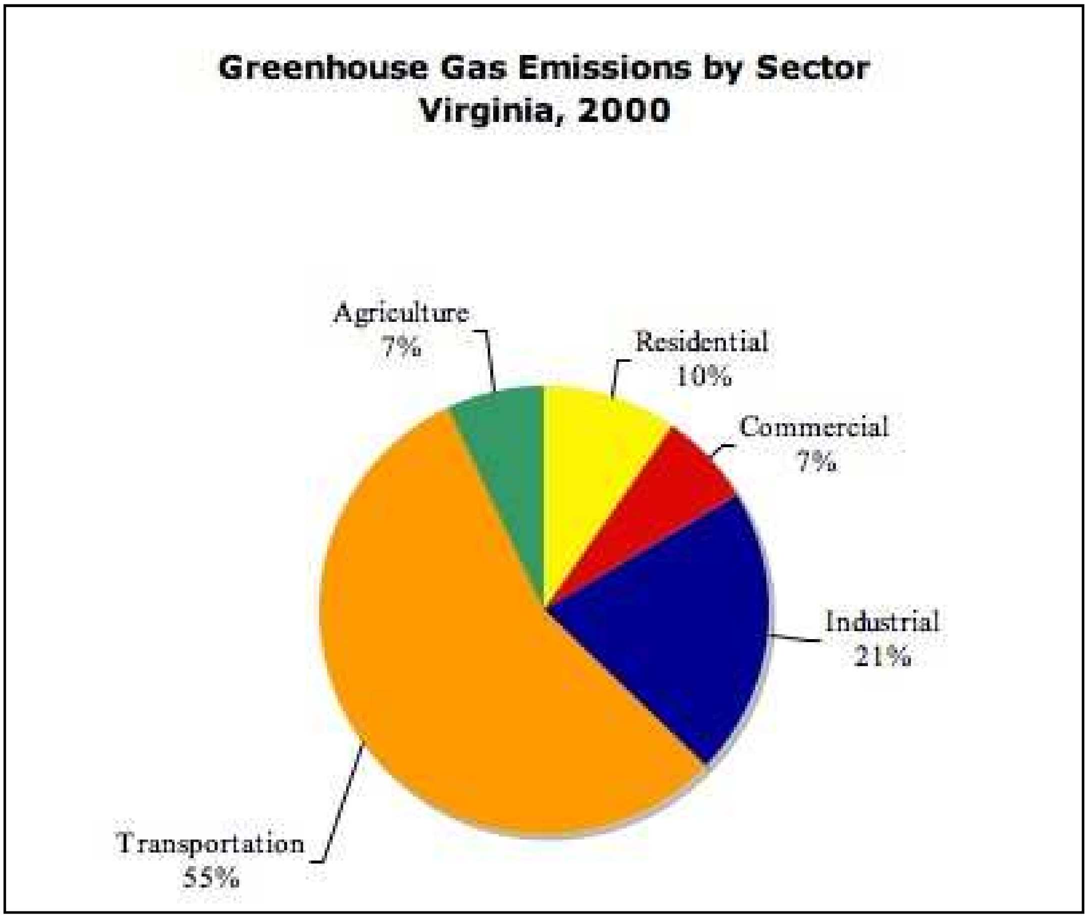


Figure 5: Virginia State Emissions. Total Emissions for the sectors above are 86.45 million metric tons (MMT) of eCO_2.

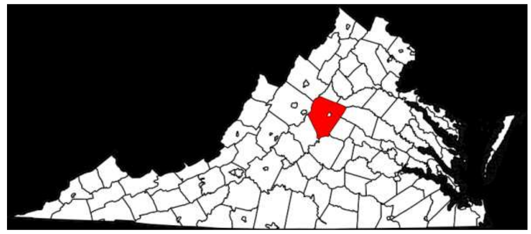
In a related effort Governor Kaine launched his *Renew Virginia* initiative in December 2008, which will include legislative and executive actions to make Virginia a leader in energy conservation, efficiency and protecting the environment. The Governor met with his economic development team to discuss strategies for attracting renewable energy companies to the Commonwealth. He also unveiled plans to establish an interagency task force and create an energy marketing plan that will attract green jobs to Virginia.

Trends observed at the national level vary at the state level. For example, transportation plays a much larger role in emissions at the state level. This can be partially attributed to the fact that the national values are an average of *all* state values. A high value of emissions in a particular category for any one state (e.g. agriculture emissions from corn production in Iowa) will affect the total national percentages, even though not all states exhibit high agriculture emissions.

The emissions information and climate changes specific to Virginia provided by this inventory will be greatly useful to the Commission on Climate Change as they identify subsequent steps that need to be taken to achieve the State's emissions reduction goal.

County Level

In July 2007 twelve pioneering U.S. counties representing over 17 million people, including King County, Washington, and Fairfax County, Virginia, launched "Cool Counties," more formally known as "The U.S. Cool Counties Climate Stabilization Initiative." In signing the associated declaration, these counties committed to reducing their greenhouse gas emissions by 80% by 2050 and helping their communities become resilient to consequent changes.



On December 5, 2007 the Albemarle County Board of Supervisors signed the *U.S. Cool Counties Climate Stabilization Declaration*, joining other counties across the nation who have pledged to reduce emissions by 80% by 2050. The County plans to follow the Five Milestones set forth by ICLEI to achieve this goal.

The ICLEI Program

The International Committee on Local Environmental Initiatives (ICLEI), commonly referred to as "Local Governments for Sustainability," is an international association that works with various local governments to support sustainable development practices. Their basic premise is that "locally designed initiatives can provide an effective and cost-efficient way to achieve local, national, and global sustainability objectives." ICLEI's international performance-based and results-oriented programs currently lend support to over 1,027 cities, towns, counties and other associations worldwide. An example of ICLEI's value in providing guidance is evident in their "Five Milestones," which aim to help jurisdictions achieve greenhouse gas emission reduction goals. The Five Milestones are summarized below.

Milestone 1: Conduct a baseline emission inventory

The baseline inventory will serve as a reference against which to measure future greenhouse gas emission reductions. More specifically, a baseline analysis will reveal which activities are causing greenhouse gas emissions, and quantify those contributions. The inventory is broken down into 2 modules: "Community" and "Government". The former includes residential, commercial, transportation and industrial sectors, while the latter includes government buildings, employee commute, public schools, and vehicle fleet. The sum of all these sector emissions yields the total amount of greenhouse gases emitted by the County of Albemarle for the year 2000, our baseline year.

Milestone 2: Set a target for greenhouse gas reduction
By participating in Cool Counties, the County has pledged to reduce emissions by 80% by 2050. However, ICLEI recommends setting further interim targets to set and track more immediate goals. The County may choose, for example, to set an interim goal for the forecast year of 2020.

Milestone 3: Establish a local action plan
An action plan including specific policies, programs and projects details how the local government plans to reach emission reduction targets by the target year. See "Part 5. Develop Local Action Plan" in this report for further details on the County's planned approach for this milestone.

Milestone 4: Implement the local action plan
This stage involves the implementation of policies, programs and projects outlined in the local action plan. In addition to implementation, ICLEI recommends routinely updating the greenhouse gas emissions inventory to track emission reduction progress.

Milestone 5: Assess, report, and modify local action plan
Ongoing periodic review, progress assessment and public reporting are critical to the achievement of emission reduction goals. The local action plan should, therefore, be modified to account for the latest changes in federal policies, latest technologies, etc.

ICLEI (International Council on Local Environmental Initiatives, www.iclei-usa.org), a non profit organization, has software based on Excel spreadsheets that allows to tabulate emissions both from municipality controlled facilities and from the community at large. ICLEI has established a network of municipalities in the US (over 350) that have already initiated projects. They are preparing a database for all the initiatives that have been implemented by their members with an evaluation of the cost effectiveness and success.

Part 3. Baseline Inventory

Methodology

ICLEI's Milestone 1, "Conduct a Baseline Inventory" involves an audit of activities known to cause or release emissions during the baseline year. The Kyoto Protocol calls for a reduction of emissions in developed countries by 5% relative to a baseline year of 1990. However, due to difficulty in accessing accurate records of community and government utility use from the year 1990, the County is using a baseline year of 2000. This is consistent with the City of Charlottesville's, the University of Virginia's, and the State of Virginia's baselines and should aid any future collaboration on emission reduction measures between these organizations.

In accordance with ICLEI guidelines, an interim year was chosen to track changes in emissions over the intervening years. The County chose 2006 as its interim year in order to assess the impact of energy efficiency-related initiatives implemented in the Municipal sector between 2000 and 2006. Also following ICLEI guidelines, a forecast year was chosen - the year 2020 - to project emissions based on a "business-as-usual" growth scenario. The forecast year's data serves as an indicator of how the County's emissions would progress over the intervening years in the absence of reduction measures.

The baseline inventory was tabulated using ICLEI's "Clean Air and Climate Protection (CACP)" software. The CACP software is an important tool that helps local governments tabulate their emissions. The software computes emissions values and provides users with a standardized methodology to report the impact of their actions. The CACP software breaks down emission categories into seven sectors and any corresponding subsectors. See Figure 6 below.

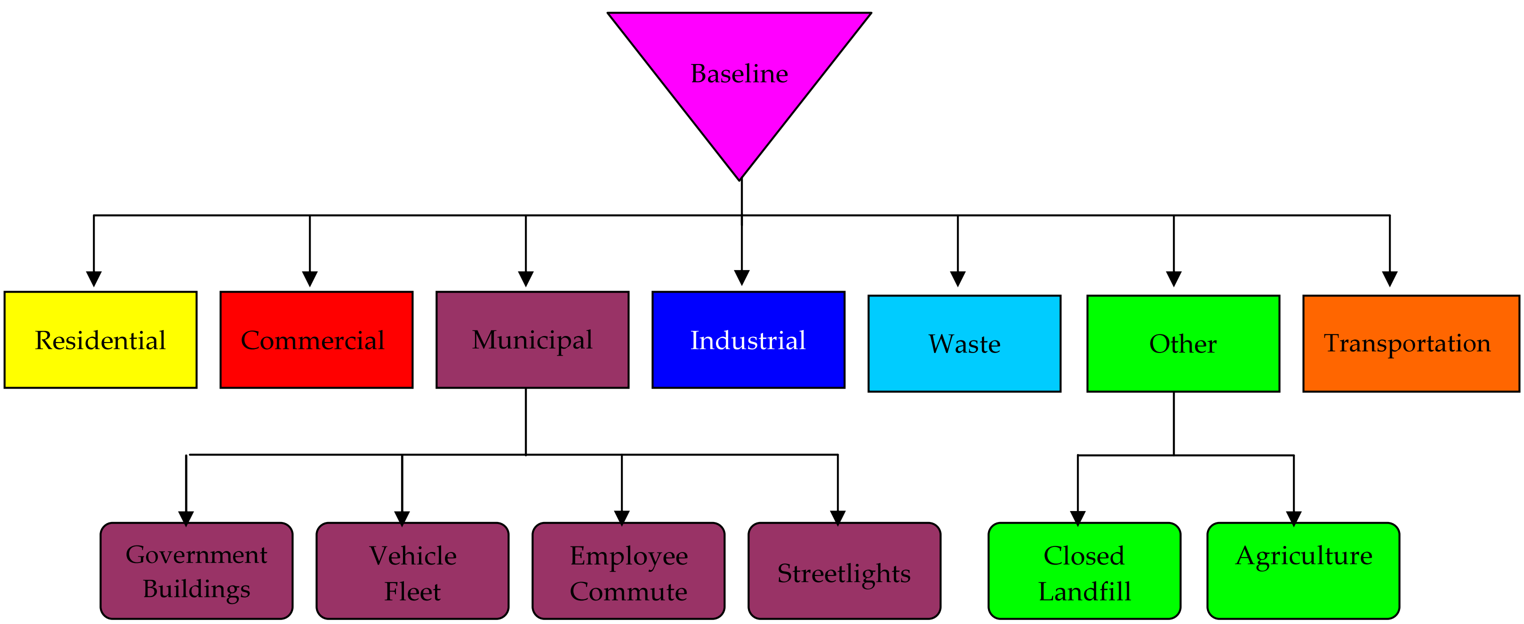


Figure 6: Baseline inventory sectors and subsectors.

Data Collection

Residential, Commercial and Industrial Energy Use

Dominion Virginia Power and American Electric Power provided electricity consumption for the residential, commercial and industrial sectors for the baseline year 2000 and the interim year 2006. Natural gas information was obtained from the City of Charlottesville. All other fuel consumption (e.g. coal, light fuel oil, propane, etc.) was determined using State and County census data. The University of Virginia was fully accounted for in the City of Charlottesville's inventory and therefore was excluded in the County's inventory to avoid double-counting.

Transportation

The Virginia Department of Transportation (VDOT) reports the daily vehicle miles traveled on all primary roads in the County of Albemarle for any given year. This information was used to calculate vehicle miles driven by County residents annually. National average percentages for commuting methods (e.g. personal vehicle, carpool, public transit, etc.) provided by the U.S. Department of Transportation were used to further categorize the annual miles driven for entry into the CACP software.

Waste

The Rivanna Solid Waste Authority (RSWA) provided information regarding the amount of waste processed annually at the Ivy Transfer Station and the Allied Waste Zion Crossroads Transfer Station. National averages for waste types (e.g. paper, food, vegetative, etc.) were used to categorize the total waste values for entry into the software.

Other

- **Closed Landfill: Keene**
  Necessary information for calculating emissions from waste-in-place at the Keene Landfill, which was closed in 1990, was available from within the General Services Department. The City of Charlottesville included the closed Ivy Landfill in its baseline inventory, so it was excluded in the County's inventory to avoid double-counting.

- **Agriculture**
  Emissions from enteric fermentation and manure management were calculated using Intergovernmental Panel on Climate Change (IPCC) methodology. Census data at the national, state and local levels were obtained from corresponding online databases to tabulate methane (CH_4) and nitrous oxide (N_2O) emissions. Refer to Appendix A for detailed agriculture emissions methodology.


Municipal

- **Government Buildings**
  Energy consumption for County office buildings, Court Square, the Charlottesville-Albemarle Regional Jail, the Blue Ridge Detention Center and other municipal buildings was obtained from the corresponding departments. The School Division's Building Services Department provided energy consumption information for all School Division facilities. When information was not immediately available, past utility bills were located at the County's storage facility.

- **Vehicle Fleet**
  The County's Vehicle Maintenance Facility provided detailed fuel consumption for the County's vehicle fleet (e.g. fire trucks, school buses, etc.) for the baseline year 2000 and interim year 2006. Vehicle and fuel classification types were used to enter fuel consumption into the software.

- **Employee Commute**
  The County's Geographic Data Services (GDS) Department calculated the shortest distance traveled by each employee to work. National average percentages for commuting methods (e.g. personal vehicle, carpool, public transit, etc.) were used to categorize total vehicle miles traveled by government employees for entry into the software. Refer to Appendix B for detailed employee commute methodology.

- **Streetlights**
  Dominion Virginia Power provided electricity consumption data for all streetlights for which the County is responsible.

County Office Building, McIntire Road

Hollymead Fire Station

Part 4. Baseline Results

Summary

Table 3: Baseline, interim and forecast year emissions data. 1 ton = 2,000 lbs.

Year	**Energy Use** Million British Thermal Units **(MMBtu)**	Total eCO_2 Emissions (Tons)
2000	13,132,671	1,503,163
2006	14,923,434	1,688,426
2020 Projection	18,424,667	2,034,650

In 2000 the County of Albemarle emitted a total of 1,503,163 eCO_2 tons. Thus, the 84,186 residents of the County emitted approximately 17.9 tons of eCO_2 each.

In comparison, the City of Charlottesville averaged 21.7 tons of eCO_2 emissions per capita in 2000.

The transportation sector comprises 52.1% of the County's baseline emissions. Residential and commercial are the two other significant sectors, contributing 27.0% and 11.5% respectively to total emissions.

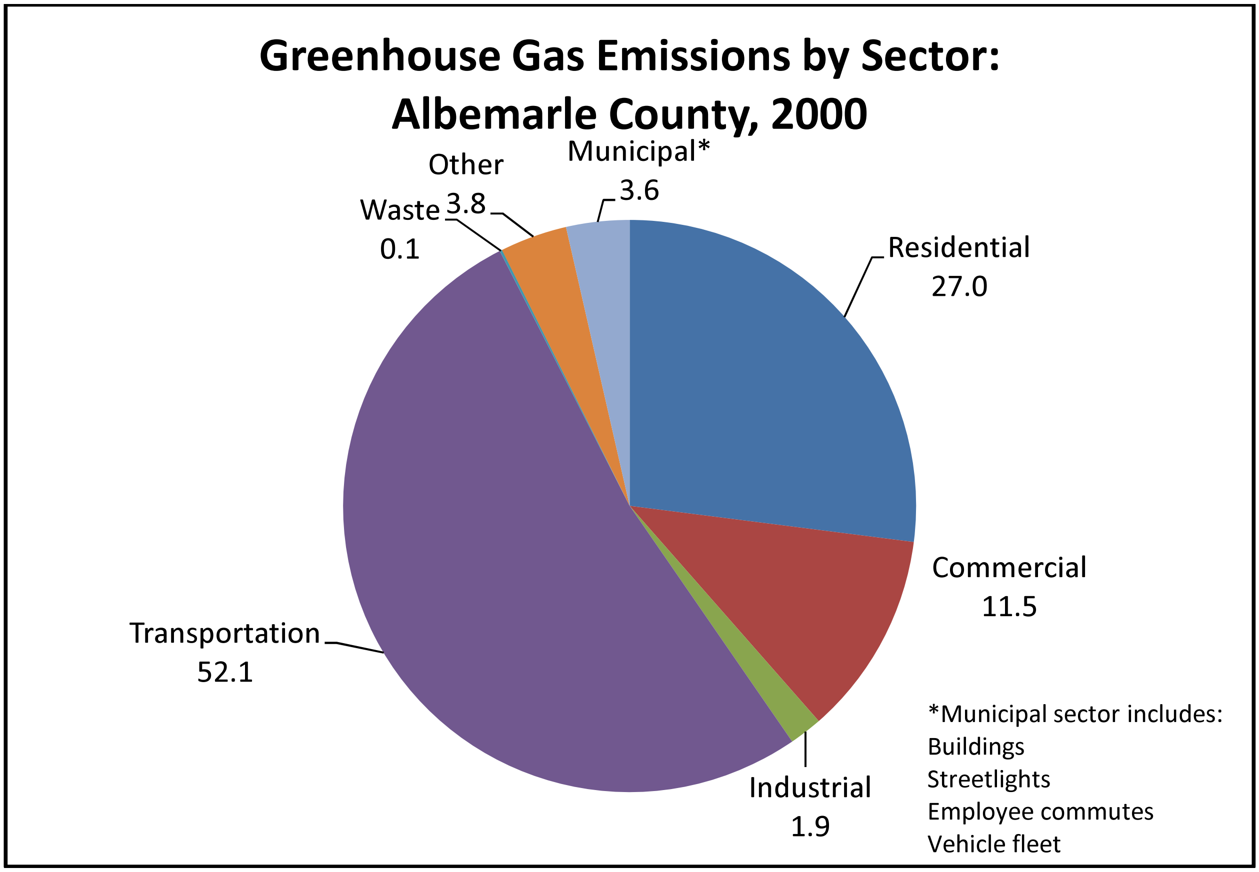


Figure 7: Greenhouse gas emissions for Albemarle County in 2000 as a percentage of eCO_2 tons.

Criteria air pollutant emissions are depicted in Figure 8. The most significant air pollutant emissions arose from the transportation sector. Carbon monoxide (CO) is emitted as a byproduct from the incomplete combustion of fossil fuels in motor vehicles.

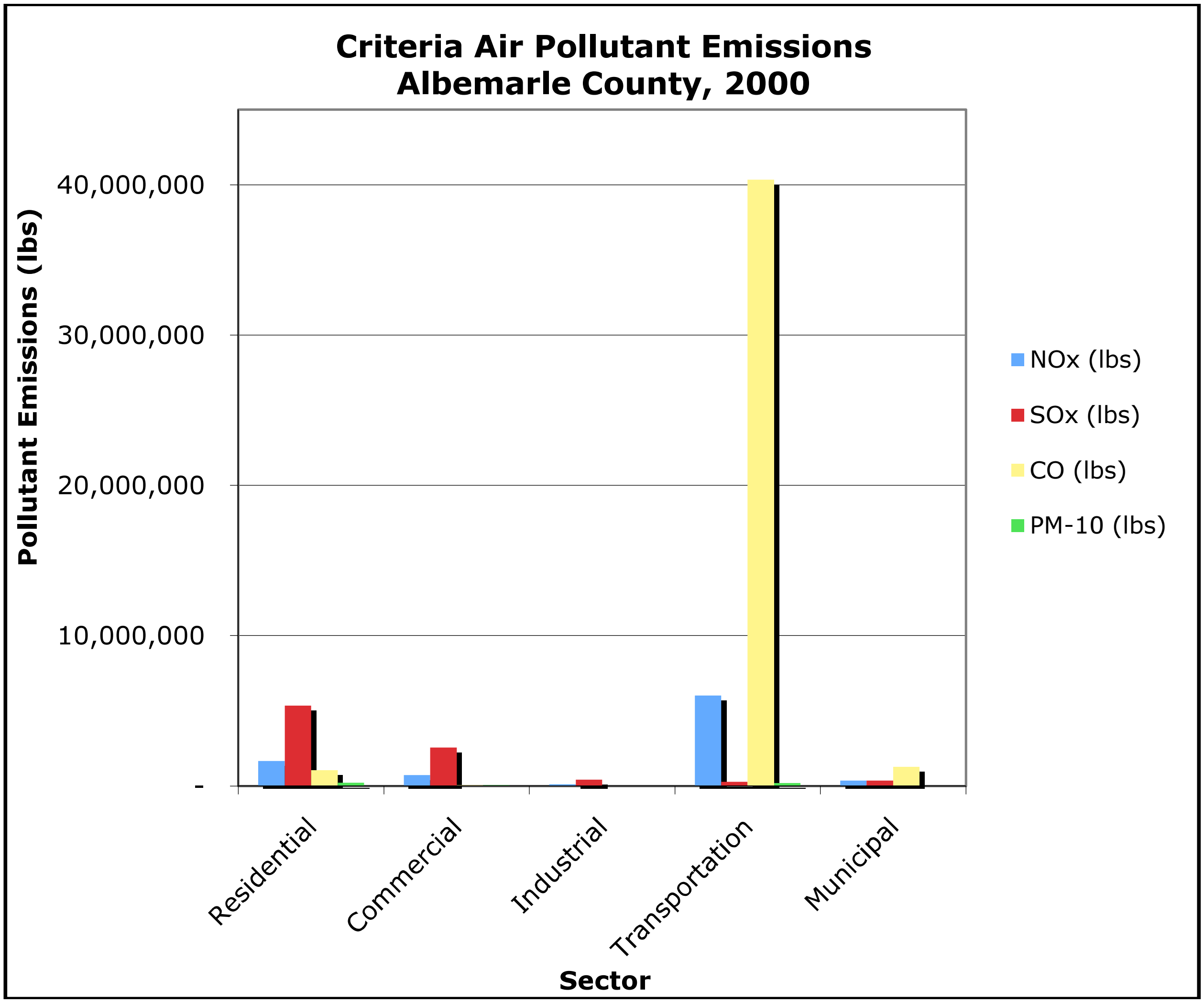


Figure 8: Criteria air pollutants emissions for the year 2000 in Albemarle County. The carbon monoxide (CO) spike in the Transportation sector represents emissions from motor vehicles.

In 2006 total County emissions increased to 1,780,476 eCO_2 tons. Specific sector-related changes are depicted on the next page in Figure 9.

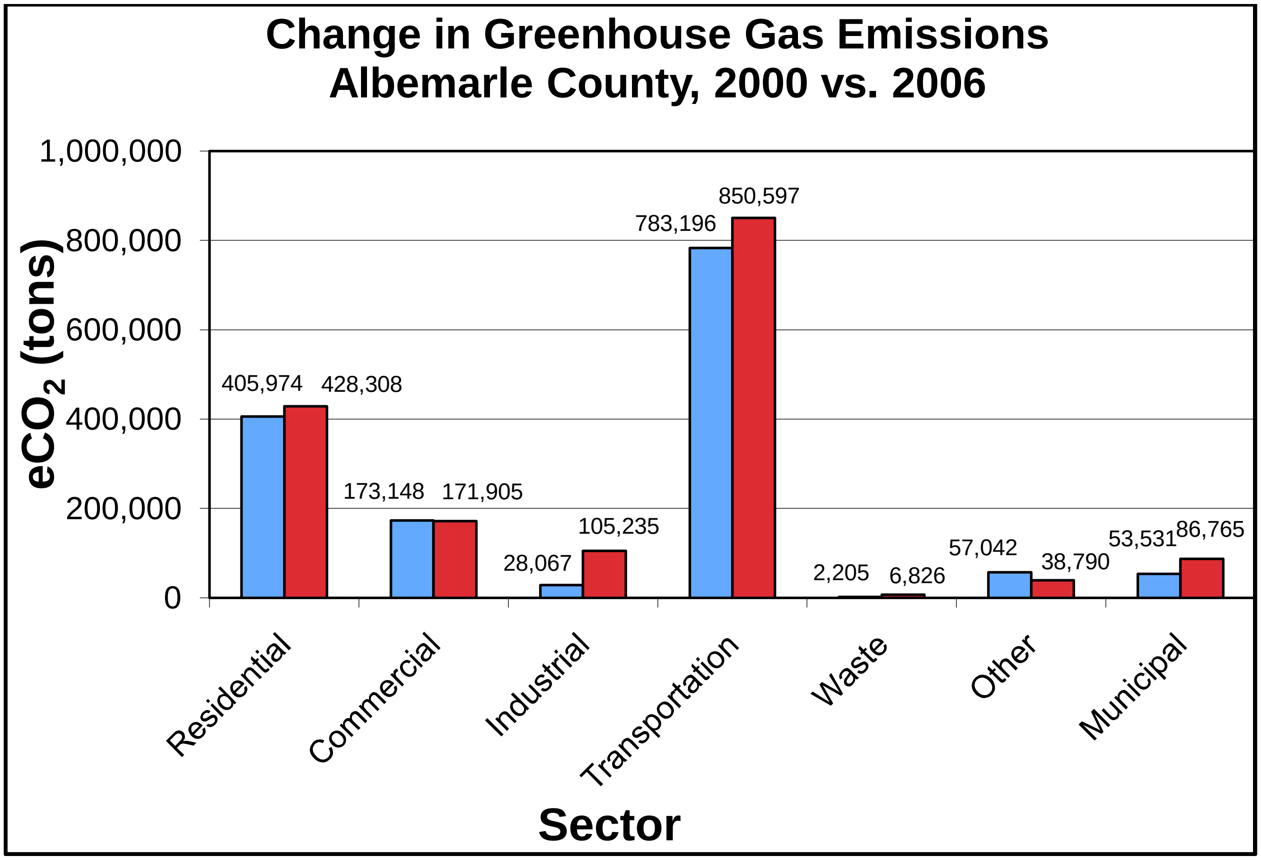


Figure 9: Greenhouse gas emission comparisons between the baseline year (2000) and the interim year (2006) for Albemarle County. All sectors showed an increase in GHG emissions except for the Commercial and Other sectors.

The CACP software allows for projections up to the year 2020 based on a "business-as-usual" scenario. This scenario assumes that governments, companies or individuals will not take any actions specifically directed at limiting greenhouse emissions. The projected emissions for 2020 in this "business as usual" scenario are 2,034,650 eCO_2 tons.

By adopting the *U.S. Cool Counties Climate Stabilization Declaration*, the County pledged to reduce emissions by 80% by the year 2050, or 2% per year beginning in 2010. Thus by the year 2020, the County would have to reduce emissions by 20% from its baseline emissions, or to 1,202,530 tons of eCO_2 (Figure 10) in order to meet this target.

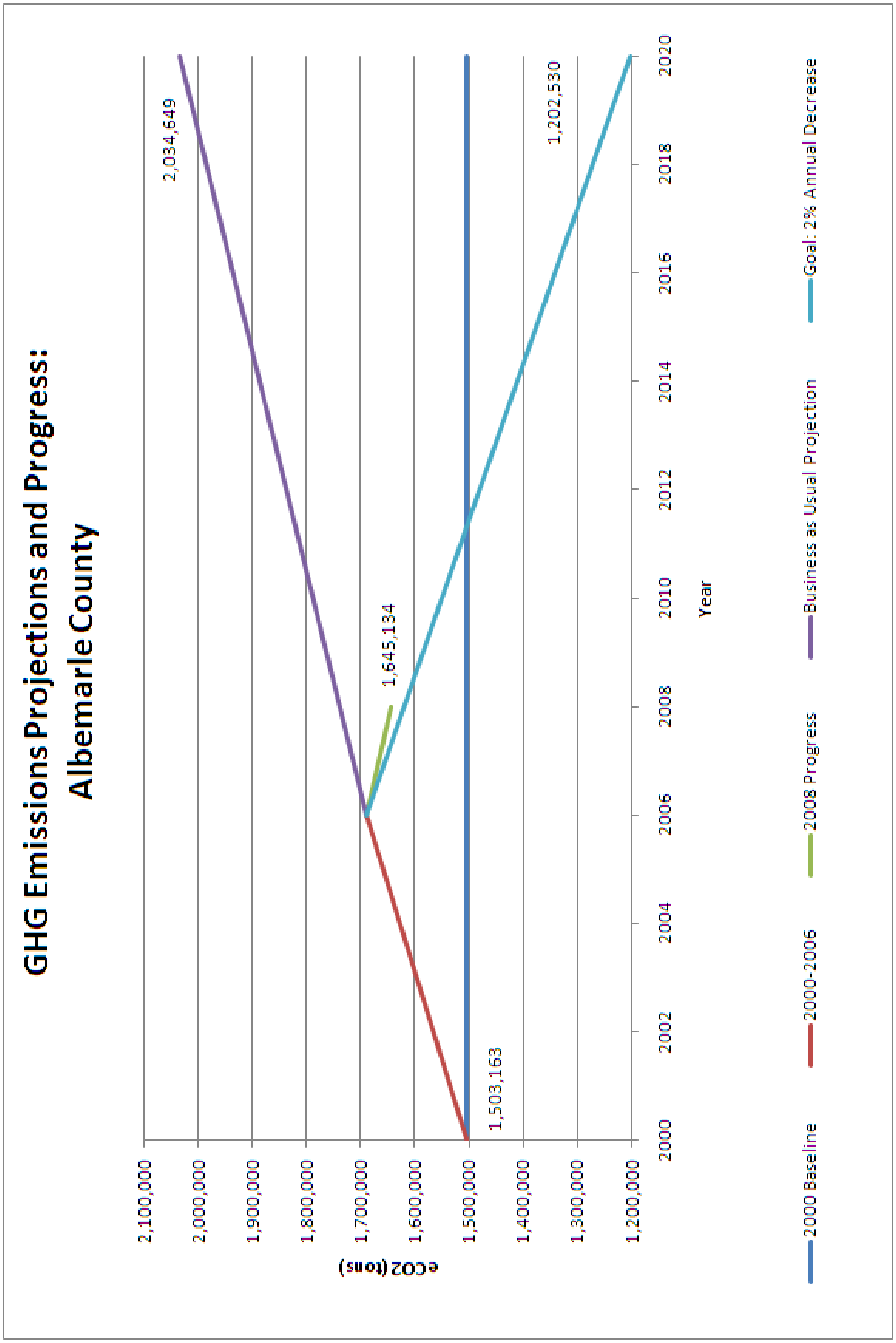


Figure 10: Baseline, Interim and Forecast year emissions data.

Residential Sector

The residential sector is the second largest contributing sector to eCO_2 emissions in the County. 27.0% of all County emissions in 2000 are attributed to residential buildings. The fuel sources of these emissions are shown in Figure 11 below. Emission factors provided by the CACP software were used to determine the emission levels resulting from each fuel source.

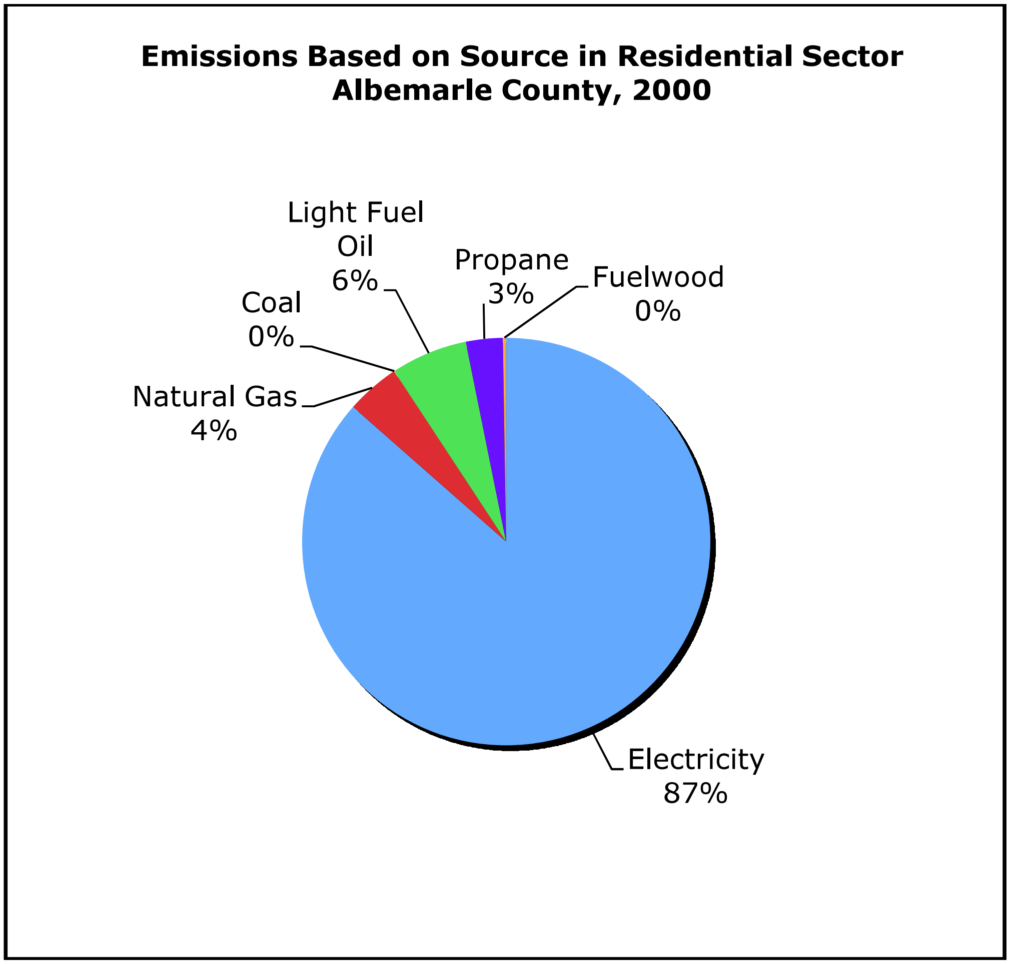


Figure 11: Greenhouse gas emissions broken down by fuel type in residential sector.

Electricity accounted for the vast majorit of residential sector emissions. Light fuel oil, natural gas, and propane accounted for the bulk of remaining emissions.

Resulting criteria air pollutant emissions in the residential sector are shown on the next page in Figure 12. These emissions include those generated from mining the source to refining processes to delivery to consumption. Sulfur dioxide (SO_2) emissions from the burning of fossil fuels, nitrous oxide (NO_x), carbon monoxide (CO) emissions from electric utilities, and particulate matter (PM_{10}) from factories all contributed to air pollution.

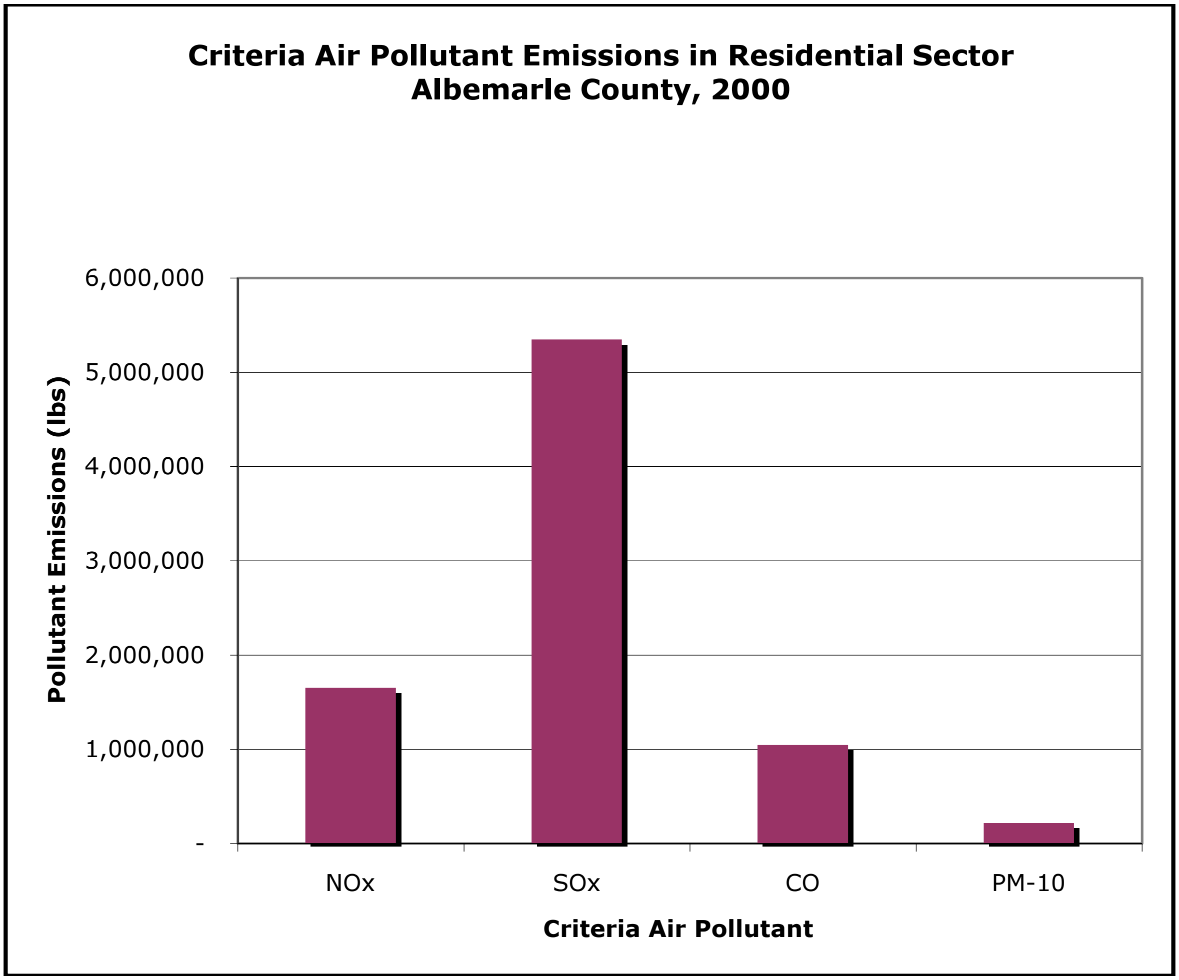


Figure 12: Criteria air pollutant emissions from residential energy consumption.

Commercial Sector

The Commercial sector contributed 11.5% to total baseline emissions for the County. Over 97% of the energy consumed in this sector was electricity (Figure 13). Natural gas trailed a distant second, providing 3% of energy consumption.

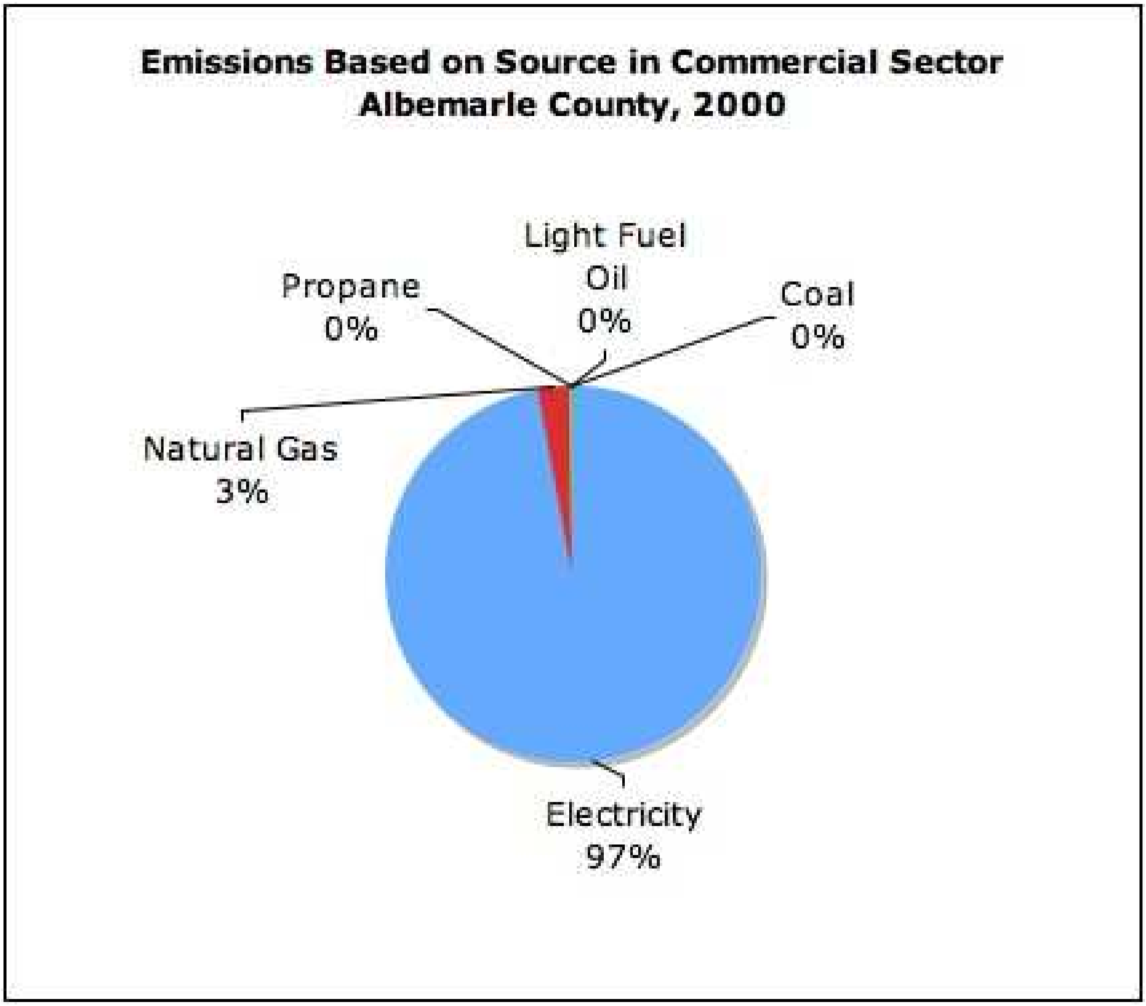


Figure 13: Greenhouse gas emissions broken down by fuel type in Commercial sector.

The two most significant criteria air pollutants emitted from the Commercial sector are sulfur dioxide (SO_2) from the burning of fossil fuels and nitrous oxide (NO_x) emissions from electric utilities (Figure 14).

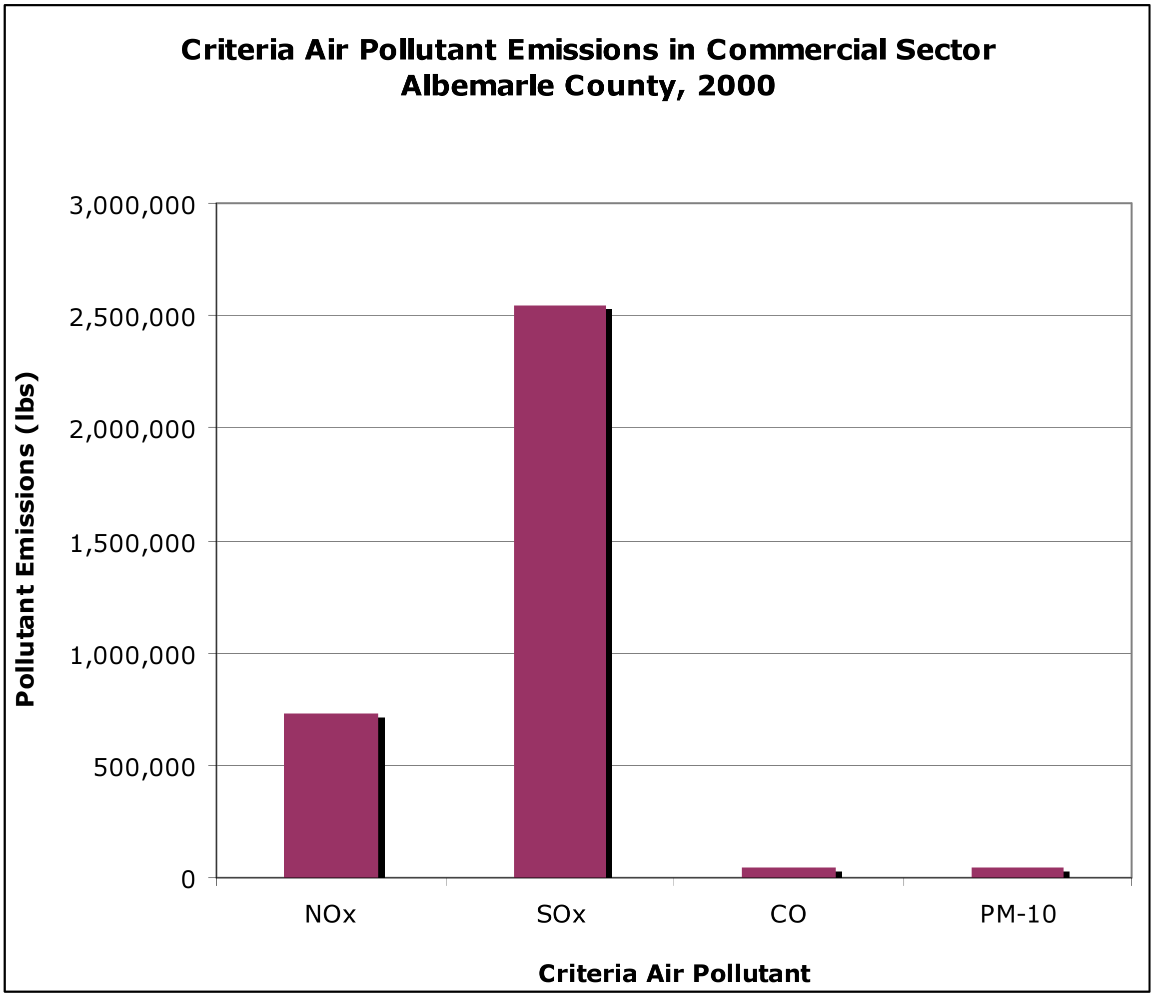


Figure 14: Criteria air pollutant emissions from commercial energy consumption.

Industrial Sector

The Industrial sector contributed only 1.9% to total County emissions for the year 2000. Similar to the Commercial sector, electricity was the dominant source of energy consumed in this sector (Figure 15). Trace quantities of propane, natural gas, light fuel oil, and coal were also consumed.

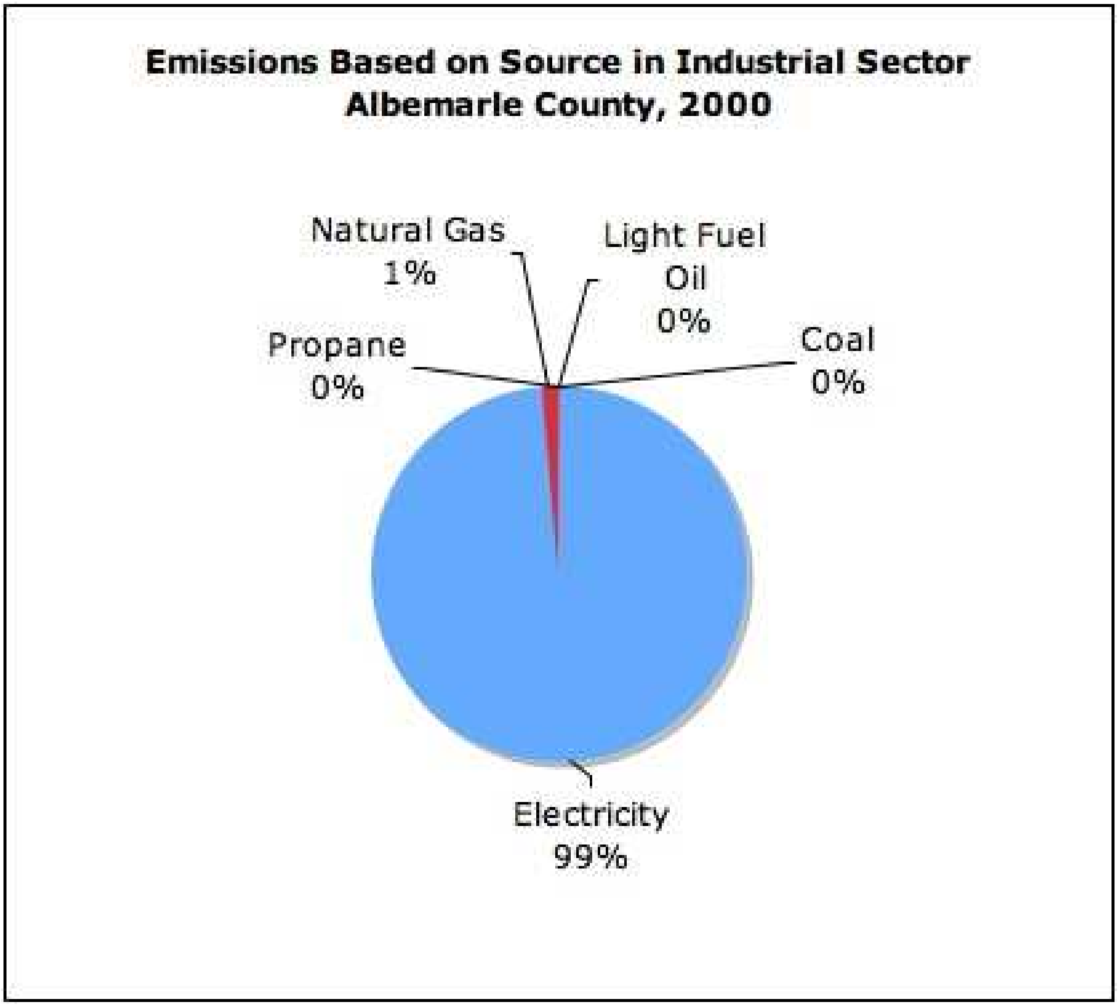


Figure 15: Greenhouse gas emissions broken down by fuel type in Industrial sector.

Note: The emissions from this sector only take into account the energy consumption by the *facilities* themselves (e.g. electricity), not any supplemental emissions from industrial processes. It is also important to note that buildings within this sector were differentiated from the Commercial sector based on Dominion Virginia Power's unique classifications. Dominion noted that some of the buildings included in the Industrial sector, for example, could actually be large "commercial" buildings, rather than facilities generally identified with industrial processes (e.g. an asphalt plant).

Emissions of electricity-related pollutants sulfur dioxide (SO_2) and nitrous oxides (NO_x) dominated this sector (Figure 16).

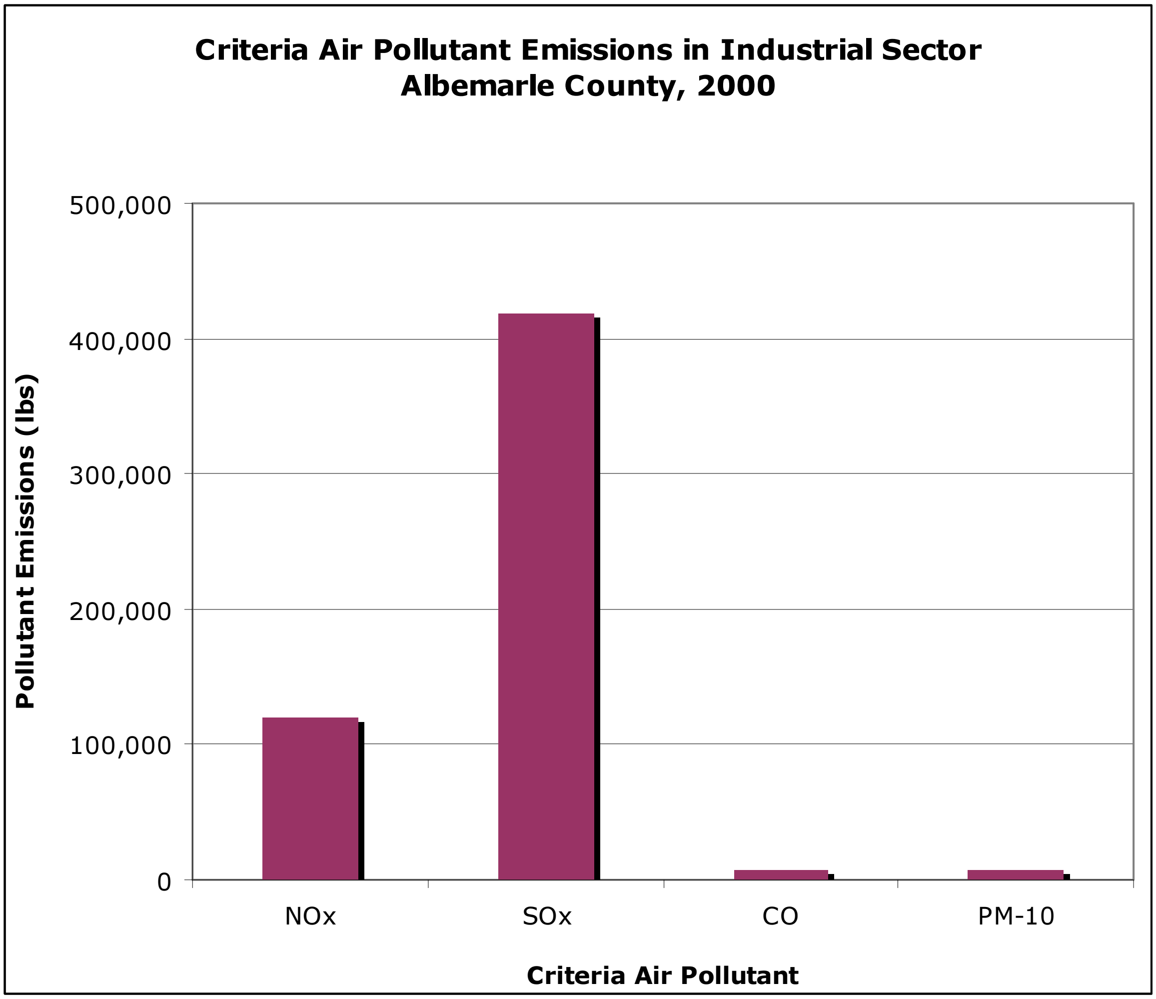


Figure 16: Criteria air pollutant emissions from industrial consumption.

Transportation Sector

Constituting 52.1% of the County's total greenhouse gas emissions, transportation was the largest contributor to our baseline emissions. The Virginia Department of Transportation's reports were used to determine miles traveled on all primary roads within the County's boundaries (and outside the City of Charlottesville limits) for the year 2000. National estimates for vehicle mode of transportation provided by the U.S. Department of Transportation were used to break down vehicle miles traveled, as well as fuel and vehicle types used. Figure 17 depicts the resulting emissions categorized by fuel source.

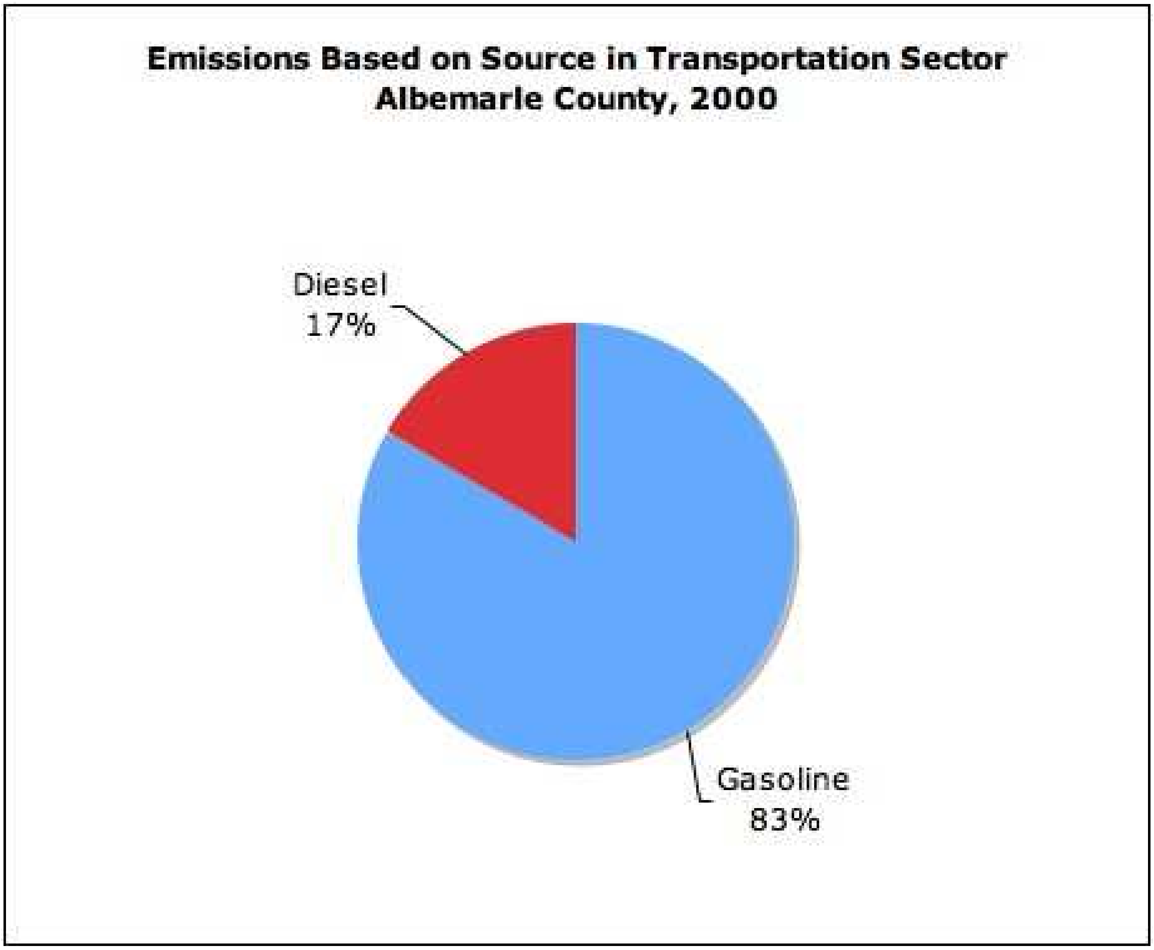


Figure 17: Greenhouse gas emissions based on fuel source for the Transportation sector.

Carbon monoxide (CO) is a common byproduct of incomplete combustion of fossil fuels in motor vehicles. Thus, it is the leading criteria air pollutant arising from the Transportation sector (Figure 18). Nitrous oxides (NO_x) are another significant pollutant resulting from the combustion processes of vehicles.

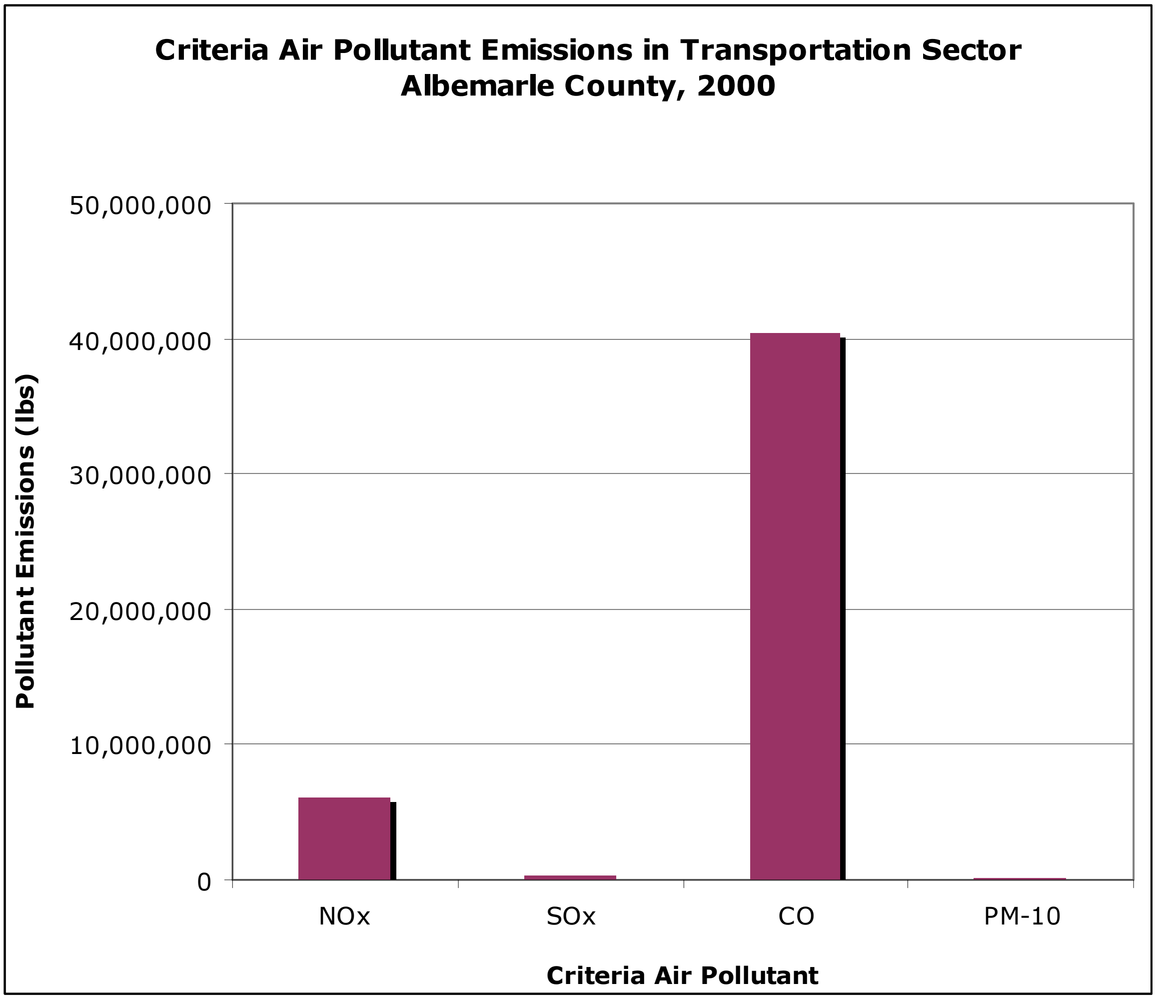


Figure 18: Criteria air pollutant emissions from transportation-related energy consumption.

Waste Sector

Comparatively, the waste sector produced an insignificant volume of greenhouse gas emissions in the County in the year 2000. County residents collectively dispose of approximately 124 tons of waste each day. Across the U.S., however, this value increases to 700,000 tons. Furthermore, for every ton of municipal waste generated downstream, there is a corresponding 70 tons of manufacturing waste generated upstream. So waste, in general, is not insignificant.

Greenhouse gases such as methane (CH_4) are emitted during the decomposition of waste. The Rivanna Solid Waste Authority (RSWA) operates a transfer station in Ivy, and all waste from that facility is transferred to a privately-owned landfill in Amelia County, VA. In addition, RSWA contracts with Allied Waste to receive waste from the City of Charlottesville and Albemarle County at its Zion Crossroads facility. All waste from this facility is then sent to the Henrico County, VA landfill. The waste figures in this sector account for the waste transferred through the Ivy Transfer Station and the Allied Waste Transfer Station for the year 2000. The total greenhouse gas emissions from waste disposed of in 2000 were calculated and plotted below (Figure 19).

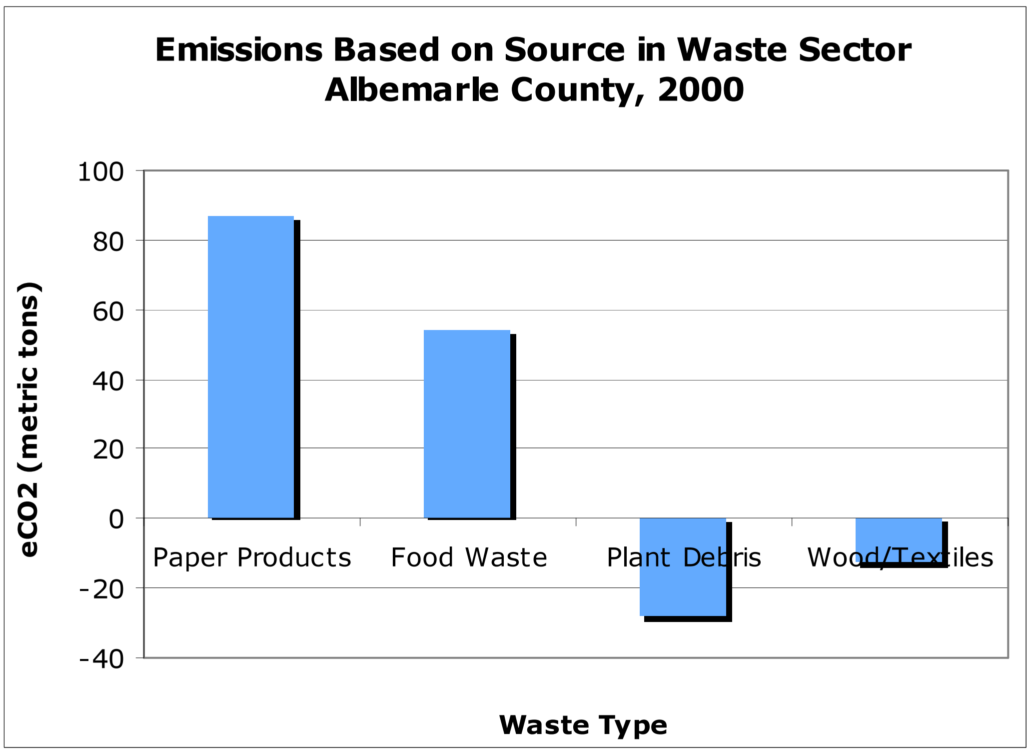


Figure 19: Greenhouse gas emissions from waste decomposition.

Methane (CH_4) is the primary greenhouse gas produced in the decomposition of paper products and food waste. Carbon dioxide (CO_2) is consumed in the decomposition of plant debris and other wood materials. Thus, CO_2 is actually removed from the atmosphere as these latter two products degrade over time, causing eCO_2 emissions to be negative in these categories.

"Other" Sector

This sector accounts for emitters of greenhouse gases or pollutants not accounted for in any other sector. Agricultural emissions and waste-in-place emissions from the closed Keene Landfill are included in this sector. Overall, this sector accounts for 3.8% of total baseline emissions for the County. Note: The City of Charlottesville included emissions from the closed Ivy Landfill in their baseline, so this was left out of the County's baseline to avoid double-counting.

Intergovernmental Panel of Climate Change (IPCC) methodology guidelines were used to calculate agricultural emissions. These emissions account for enteric fermentation (animal digestive processes) and manure management processes. For specific, detailed methodology, refer to Appendix A.

Although the Keene Landfill was closed in 1990, existing waste in the closed landfill continues to decompose and generate greenhouse gas emissions. These emissions account for the remaining 37% of emissions in the "Other" sector (Figure 20).

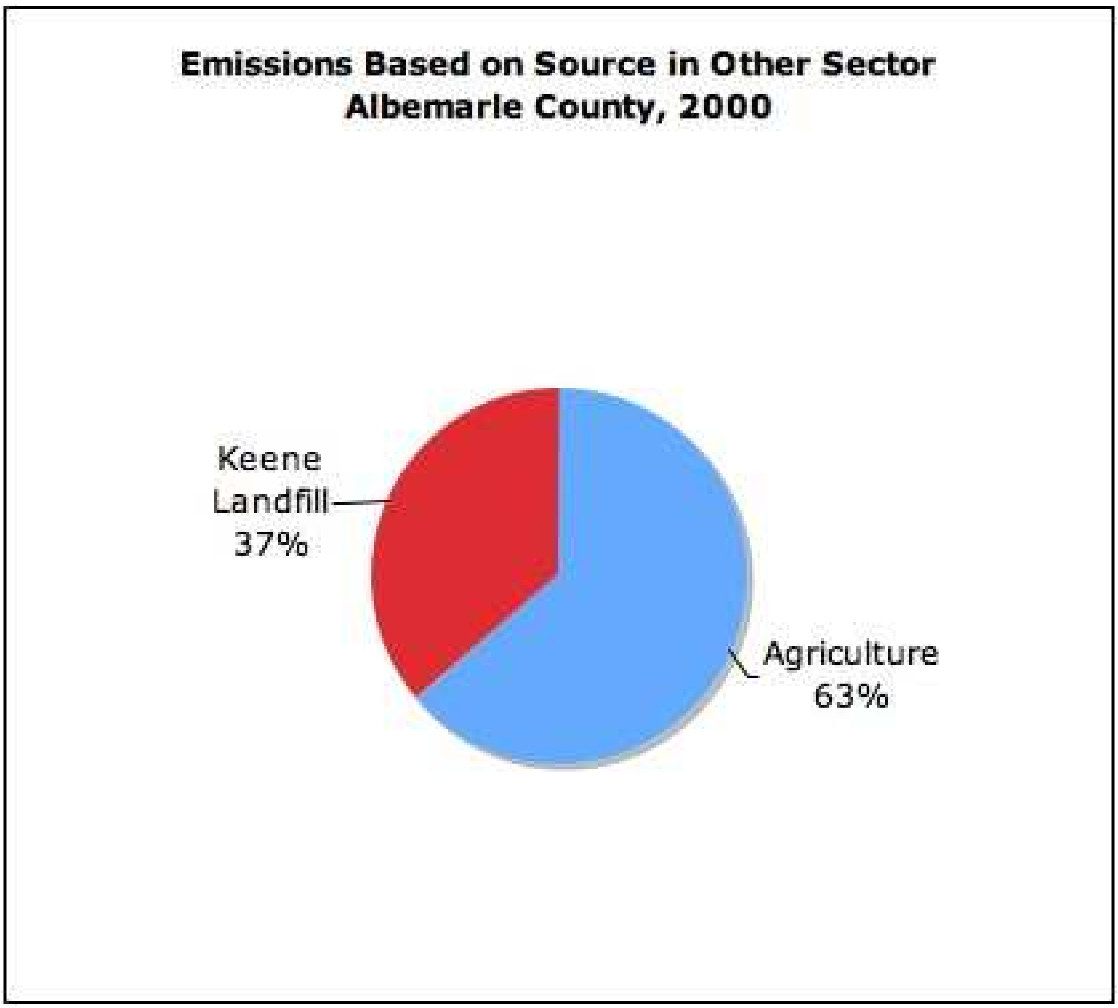


Figure 20: Greenhouse gas emissions from agricultural processes and the closed Keene Landfill.

Municipal Sector

Due to readily-available information, the Municipal sector's energy consumption can be categorized into four subsectors: government buildings, employee commute, vehicle fleet, and streetlights. The breakdown of emissions among these subsectors is shown in Figure 21.

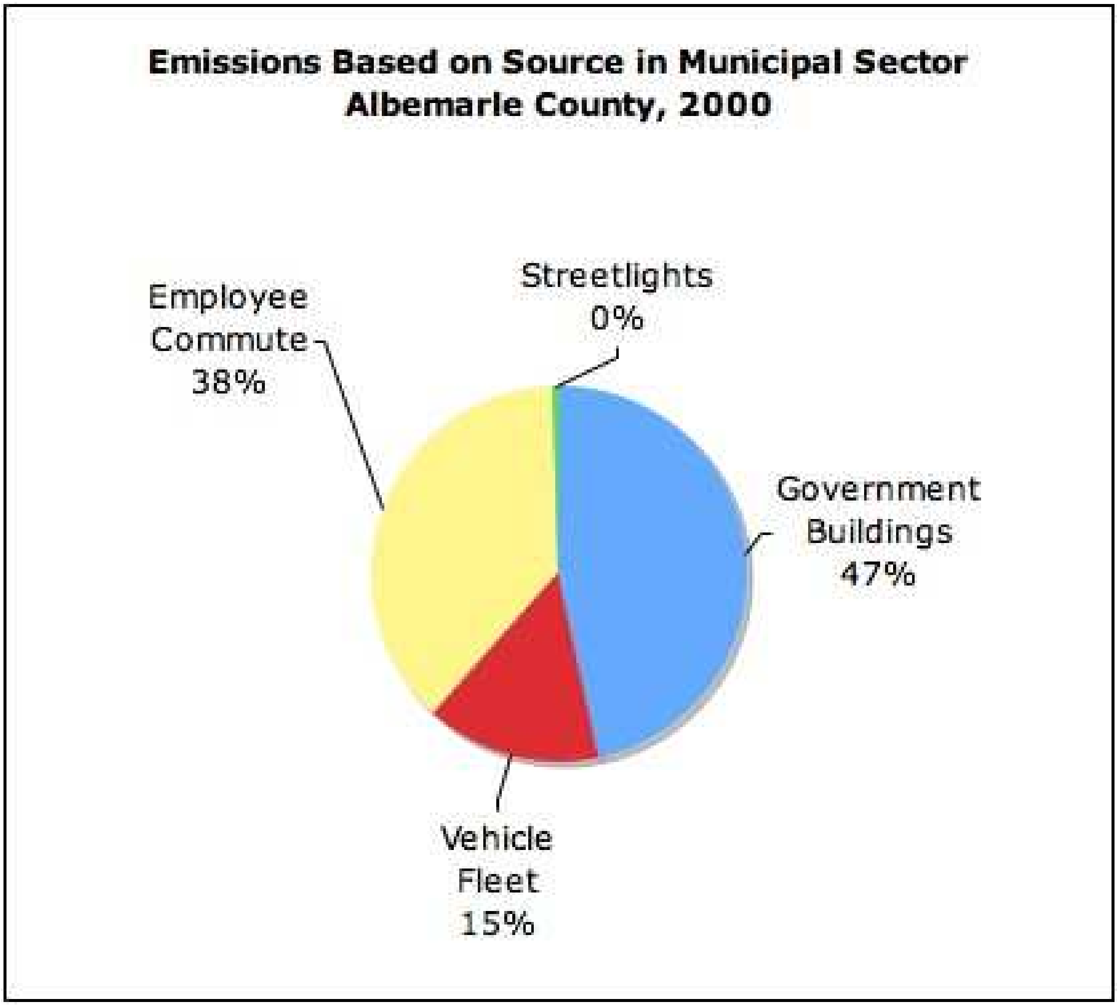


Figure 21: Emissions broken down by subsectors within the Municipal sector.

Government buildings comprise almost half of Municipal emissions. These include all government-owned-and-operated buildings such as schools, county office buildings, fire stations, etc.

Note: The Blue Ridge Detention Center is wholly accounted for in the County's baseline and interim year emissions even though it is used by other municipalities as well.

Employee commuting accounts for 38% of the emissions from the Municipal sector. This subsector includes emissions associated with travel to and from work by County employees. Using home and work addresses catalogued, the Geographic Data Services (GDS) Department calculated the shortest distance traveled by each employee from their home to their work address. The remaining 15% of this sector's emissions arise from vehicle fleet use. These include all government-owned vehicles such as school buses, fire trucks, and County fleet vehicles. Information regarding the vehicle, fuel types and amount of fuel consumed were provided by the Vehicle Maintenance Facility for entry into the software.

A small fraction of these emissions can be attributed to streetlights. Streetlight electricity consumption was calculated by compiling utility bills from Dominion Virginia Power.

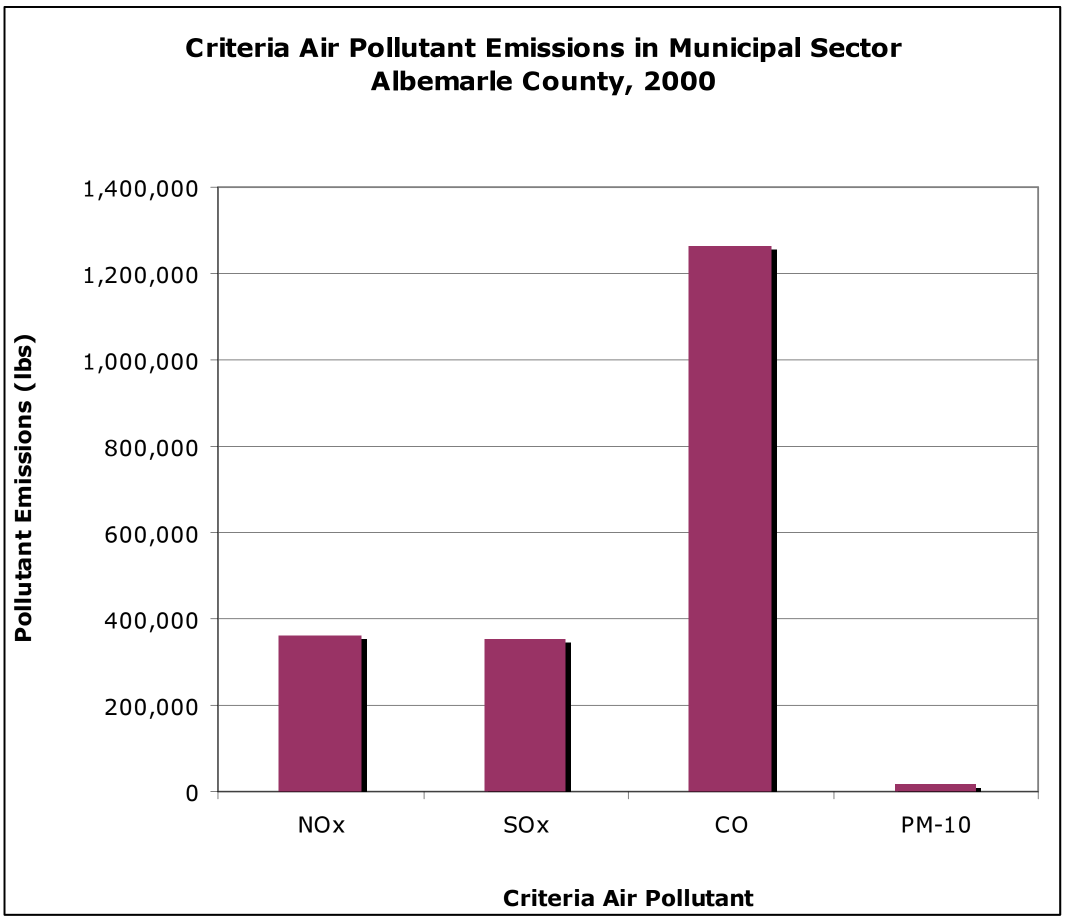


Figure 22: Criteria air pollutant emissions from the Municipal sector.

Government building and government transportation emissions mainly include carbon monoxide (CO), sulfur dioxide (SO_2), and nitrous oxides (NO_x) (Figure 22). The majority of emissions come from CO, since more than half of the emissions in this sector arise from fossil fuel combustion in motor vehicles.

Trends

Interim Year Emissions: 2006

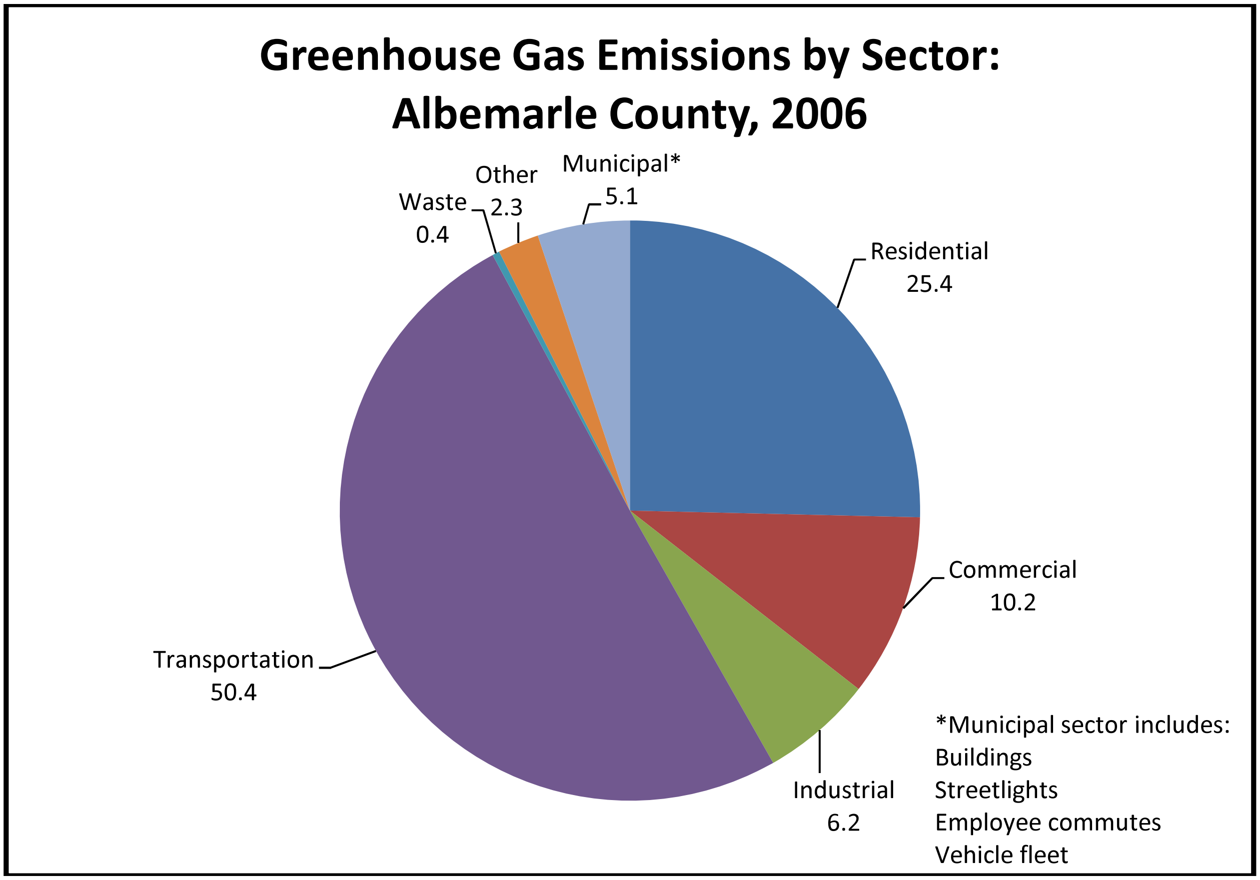


Figure 23: 2006 interim year emissions.

An interim year of 2006 was chosen to track emissions growth since the baseline year 2000. Residential emissions increased by about 3.4%, while the industrial sector increased by nearly 275%.

Emissions from the Transportation sector increased from 783,196 tons in 2000 to 850,597 tons in 2006. Although this sector experienced an absolute increase, in 2006 it accounted for only 50.4% of total emissions. This indicates that overall County emissions rose more rapidly than Transportation sector emissions.

The Municipal sector also increased its total emissions in 2006 primarily because of the increased number of buildings that fell under the County's jurisdiction between 2000 and 2006. The County assumed greater overhead energy consumption with the opening of the 5th Street County Office Building and the Monticello Fire Station. In addition, the Charlottesville-UVa-Albemarle County Emergency Communications Center (ECC/911) was wholly accounted for in this sector for the year 2006, since the City of Charlottesville included it in their baseline emission calculations but exempted it from their interim year calculations.

Forecast Year Emissions: Year 2020

A forecast year of 2020 was chosen in order to be consistent with the City of Charlottesville's future projections. The CACP software estimates that emissions will increase to 2,034,650 tons of eCO_2 under the "business-as-usual" scenario. However, this estimation most likely underestimates what the actual emissions would be, since other institutions will likely fall under the County's jurisdiction by 2020. Most notably, in the Community sector, Martha Jefferson Hospital (which is now accounted for in the City of Charlottesville's emissions) will move into the County's emissions calculations from the year 2012 onwards. Another example is the new Hollymead Fire Station, which will increase Municipal sector emissions.

Part 5. Local Climate Action Planning Process

Because the forecasted 2020 projection is lower than our baseline emissions, and much lower than our "business as usual" projection, it is important to realize that without aggressively implementing climate protection measures, we will not be able to meet our overall target of 80% emissions reduction by the year 2050. This is indicated in Figure 10, wherein from 2000 to 2006 we observed constant increase in emissions and we predicted further increase under a "business as usual" scenario.

Therefore, the next necessary step is to engage in a Local Climate Action Planning Process. The Board of Supervisors and County staff, along with officials from the City of Charlottesville and the University of Virginia, have expressed a keen interest in collaborating on such a process. In January 2009 the Albemarle County Board of Supervisors and the Charlottesville City Council unanimously passed resolutions in support of the County, City and University working together to address energy efficiency and climate change (see Appendix E for Board of Supervisors Resolution).

On a Collaborative Approach

In December 2007 Governor Kaine established the Governor's Commission on Climate Change to address global warming and its impacts on Virginia. The Commission was comprised of over 40 citizens who were "broadly expert and philosophically diverse." Their final report, published in December 2008, includes many useful recommendations that will inform public policy and legislation in the short and long-term. Governor Kaine understood that emissions causing climate change are linked to fossil fuel energy use, and this use encompasses topics as diverse as land use planning, transportation, the built environment, industry, waste management, and renewable energy.

The use of a Steering Committee and Focus Groups is typically considered "best practice" to build community consensus and involvement with respect to a complicated issue. As is evident in this baseline report, the majority of the County's emissions result from the residential, transportation, and commercial sectors of our community (as opposed to industry or agriculture). To address them, we will have to garner the support and participation of the public in programs and initiatives proposed. Not only will the Steering Committee and Focus Groups provide insight into stakeholder positions, they will also vet proposals and strategies, and help communicate outcomes to the community at large. The Steering Committee's composition of influential representatives from the County, City, and UVa – coupled with the participation of well-respected members of our community – will help ensure that recommendations for strategies and programs are relevant, practical, and will serve to further the collective good.

While staff cannot predict the details of the final Local Climate Action Plan at this stage, our goal is to find ways to work collaboratively on issues that affect us all, and in doing so pool our resources and maximize impact. One example of an issue that affects us all is energy efficiency.

Is it possible for our area to develop a large-scale, self-funded energy efficiency program similar to the Cambridge Energy Alliance (CEA) developed in Cambridge, Massachusetts? Such a program would help lower the community's carbon footprint, save participants money, and provide exciting educational and outreach opportunities to UVa faculty and students. With respect to a Local Climate Action Plan, it is expected that each organization will continue to focus on issues particular to their budget, administration, and goals, while also exploring synergistic ways to work together. Lastly, this approach will give us all the opportunity to better understand each entity's strengths and limitations when it comes to addressing climate change in our community.

Our goal is to establish a Steering Committee in early 2009 and quickly begin the Local Climate Action Planning Process. It is anticipated that outcomes from this process will shape public policies and programs as we individually and collectively look to reduce our contribution to the world's greenhouse gas emissions. The Steering Committee will ultimately issue a report outlining strategies that are particular to each organization, as well as those that present shared opportunities. In the end, each participating entity will have to determine what is appropriate for implementation and how that implementation will take place. However, the expectation is that in those areas where cooperation and synergy are needed, Charlottesville, UVa, and Albemarle will share an approach.

Figure 24 below is a graph depicting a combined baseline inventory (year 2000) for the City and the County. This figure underscores the need to work together in order to maximize our impact, and also illustrates the necessity of involving representatives from all sectors at the beginning of this process. Furthermore, since many residents' lives cross City-County lines multiple times a day, and staff who work at UVa are also members of our greater community, it makes sense that this issue be addressed collaboratively.

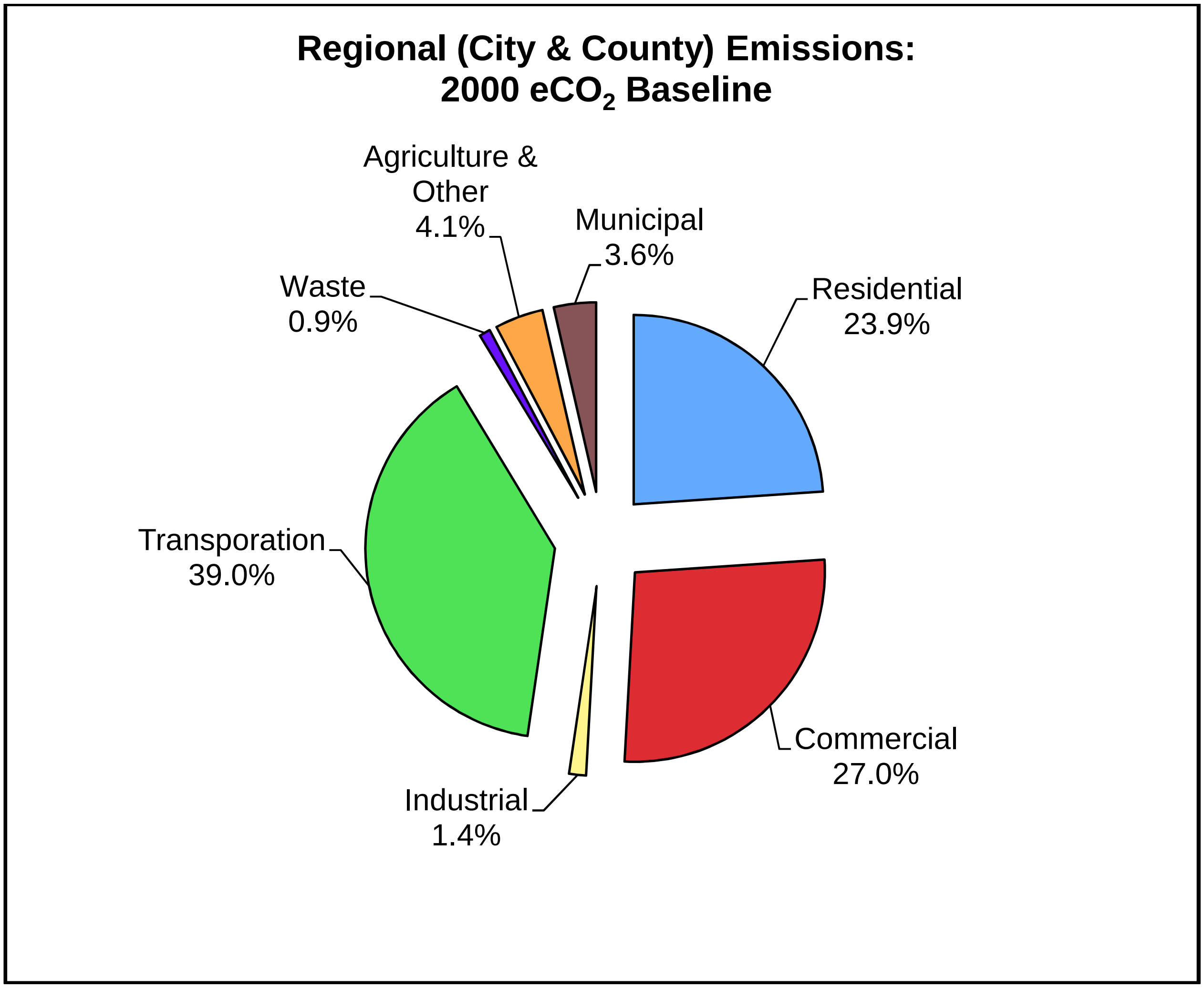


Figure 24: Combined regional emissions for the City of Charlottesville and the County of Albemarle. The University of Virginia was included within the commercial sector of the City of Charlottesville's baseline emissions.

"Much more likely than not, global warming is upon us. We should expect weather patterns to continue to change and the seas continue to rise, in an ever worsening pattern, in our lifetimes and on into our grandchildren's. The question has graduated from the scientific community: climate change is a major social, economic, and political issue. Nearly everyone in the world will need to adjust."

Spencer R. Weart, *The Discovery of Global Warming*

GLOSSARY

Baseline Year – A specific year of emissions against which future emissions and emission targets are measured against; the year itself is typically 1990 or 2000 depending on the institution's availability of resources.

Carbon Dioxide (CO_2) – The most common greenhouse gas, consisting of a single carbon atom and two oxygen atoms. CO_2 is released by respiration, the burning of fossil fuels, and is removed from the atmosphere by photosynthesis in green plants. During pre-industrial times, the CO_2 concentration was measured to be approximately 280 parts per million (ppm). In 1990, this value increased by 25% to 353 ppm. Current values of CO_2 are the highest they have been in the last 160,000 years. CO_2 concentrations are increasing at an annual rate of 0.5% (or 1.8 ppm) due to anthropogenic emissions.

Carbon Dioxide Equivalent – See "eCO_2."

eCO_2 – Also known as "carbon dioxide equivalent", a common unit for combining emissions of greenhouse gases with different levels of impact on climate change. It is based on the global warming potential of each greenhouse gas. For carbon dioxide itself, emissions in tons of CO_2 and tons of eCO_2 are the same, whereas for nitrous oxide and methane, stronger greenhouse gases, one ton of emissions are equal to 310 tons and 21 tons of eCO_2 respectively.

Emission Factors – These factors denote the ratio of emissions of a particular pollutant (e.g., carbon dioxide) to the quantity of the fuel used.

Emissions Inventory – The quantification of all emission-related activities within a jurisdiction's boundaries during a particular year.

Enteric Fermentation – Enteric fermentation occurs when methane (CH_4) is produced in the rumen of animals such as cattle, as microbial fermentation takes place. Most of the CH_4 byproduct is belched by the animal; however, a small percentage of CH_4 is also produced in the large intestine and passed out as gas.

Forecast Year – Any future year in which predictions are estimated for through growth multipliers applied to the base year.

Greenhouse Effect – A naturally occurring process whereby the lower atmosphere and the earth's surface is heated because infrared energy emitted by the earth is reflected back towards the earth by greenhouse gases.

Greenhouse Gases (GHG) – Gases which reflect part of the earth's emitted infrared radiation. Includes CO_2, H_2O, CH_4, N_2O, SF_6, PFCs, HFCs, etc.

Hydrofluorocarbons (HFCs) – GHGs used primarily as refrigerants; composed of hydrogen, fluorine, and carbon.

Intergovernmental Panel on Climate Change (IPCC) – An organization established jointly by the United Nations Environment Program and the World Meteorological Organization in 1988 to assess information in the scientific and technical literature related to all significant issues relating to climate change. IPCC publications provide a technical analysis of the science behind climate change and guidance on quantification procedures for GHG emissions.

Interim Year – Any year for which an emissions inventory is completed that falls between the baseline year and the target year. Completing an emissions inventory for an interim year is useful in determining a jurisdiction's progress towards meeting their emission reduction goals.

Kilowatt Hour (KWh) – The electrical energy unit of measure equal to one thousand watts of power supplied to, or taken from, an electric circuit steadily for one hour. (A Watt is the unit of electrical power equal to a current of one ampere under a potential difference of one volt, or 1/746 horsepower.)

Local Action Plan – A comprehensive plan for a community that includes an emissions analysis, emissions reduction target, emissions reduction strategy, and emissions reduction implementation strategy.

Methane (CH_4) – A GHG resulting from the anaerobic decomposition of vegetative materials in wetlands, urban landfills, and rice paddies, the production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. The principle constituent of natural gas, methane is a single carbon atom linked to four hydrogen atoms.

Methane Recovery Factor – A measurement of the percentage of methane produced that is being captured at a landfill. For example, a landfill that is capped, lined, and has a methane extraction system that effectively captures all released methane would have a Methane Recovery Factor of 100.

Metric Ton(ne) – Common international measurement for the quantity of GHG emissions, equivalent to 1000 kilograms, or about 2,204.6 pounds or 1.1 short tons.

Nitrous Oxide (N_2O) – A potent GHG produced in relatively small quantities. It is composed of a two nitrogen atoms and a single oxygen atom and is typically generated as a result of soil cultivation practices, particularly during commercial and organic fertilizer use, fossil fuel combustion, nitric acid production, and biomass burning.

Perfluorocarbons (PFCs) – A class of GHGs consisting of carbon and fluorine compounds. Originally introduced as alternatives to ozone depleting substances, they are typically emitted as by-products of industrial and manufacturing processes.

Sectors – Within CACP, records are organized into sectors that contain similar related activities or emissions sources. The sectors for the community module include: Residential, Commercial, Industrial, Transportation, Waste, and Other. The sectors in the municipal module include: Buildings, Vehicle Fleet, Employee Commute, Streetlights, Sewage, Waste, and Other.

Sink – Any process, activity or mechanism that results in the net removal of greenhouse gases from the atmosphere.

Sulfur Hexafluoride (SF_6) – a GHG consisting of a single sulfur atom and six fluoride atoms. Primarily used in electrical transmission and distribution systems.

Target Year – The year by which the emissions reduction target should be achieved. Often also used as a "Forecast Year."

United Nations Framework Convention on Climate Change (UNFCCC) – An international environmental treaty produced at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. The UNFCCC provides an overall framework for international efforts to mitigate climate change. The Kyoto Protocol is a revised version of the UNFCCC.

Vehicle Miles Traveled (VMT) – Annual vehicle miles traveled in an area. Distance traveled on roads is routinely calculated by the Virginia Department of Transportation.

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APPENDIX A: AGRICULTURE METHODOLOGY

The Clean Air and Climate Protection (CACP) software breaks down greenhouse gas emissions by source into six major sectors (i.e., residential, commercial, industrial, etc.). A seventh sector was added labeled "Other" to account for emissions not already included by the remaining sectors. Agricultural emissions from the County of Albemarle's livestock and related waste were included under this seventh sector.

The CACP software does not include an agriculture section in the software most likely due to data unavailability and the complexity of calculations. Furthermore, currently, most of the communities that conduct GHG inventories are urban so there has been little need for them to streamline calculation of agriculture emissions (Sonoma County GHG).

Agricultural activities contribute directly to emissions of greenhouse gases through a variety of processes (EPA 2008). Animals produce greenhouse gases such as methane and carbon dioxide during the digestion process. Other greenhouse gases, primarily nitrous oxide, arise from the microbial degradation of manure. Additional emissions result from degradation processes in uncovered waste lagoons and anaerobic digesters (Pew Center 2008). Refer to Table 1 below for additional breakdowns of contributing agricultural activities.

Methane (CH_4) and nitrous oxide (N_2O) are the primary greenhouse gases emitted by agricultural activities. CH_4 emissions from enteric fermentation and manure management represent about 23% and 7% of total CH_4 emissions from anthropogenic activities, respectively. Of all domestic animal types, beef and dairy cattle are by far the largest emitters of CH_4. Rice cultivation and field burning of agricultural residues are minor sources of CH_4. Agricultural soil management activities such as fertilizer application and other cropping practices were the largest source of U.S. N_2O emissions, accounting for 72%. Manure management and field burning of agricultural residues were also small sources of N_2O emissions (EPA 2008).

Table 4. Primary greenhouse gas emissions broken down by agricultural activities.

	CH_4	N_2O
Enteric Fermentation	√	
Manure Management	√	√
Rice Cultivation	√	
Agricultural Soil Management		√
Field Burning of Agricultural Residues	√	√

Globally, greenhouse gas emissions from all livestock operations account for 18% of anthropogenic greenhouse gas emissions, exceeding those from the transportation sector (Steinfeld et. al., 2006). In the United States, agriculture accounts for 7.4% of the total US release of greenhouse gases (EPA 2007a). At the county level, agriculture emissions account for approximately 1.5% of the County of Albemarle's baseline emissions.

CH_4 Emissions

Enteric Fermentation

Background

Enteric fermentation is a normal digestive process in animals (EPA 2008). Carbohydrates are broken down by micro-organisms into simple molecules which the animals' bodies can use more readily (IPCC 2006). CH_4 is released as a by-product of this process through either exhalation or eructation[1] by the animal. The amount of CH_4 released is a function of the animal characteristics (i.e., age, weight, type of digestive tract) and feed characteristics (i.e., quantity and quality). For example, cattle emit more CH_4 than swine on a per-animal basis because the former digest coarse plant material in their large "fore-stomach" while the latter digest food in their large intestines (EPA 2008).

Methodology

The IPCC has outlined three approaches to calculating CH_4 emissions from enteric fermentation: Tier 1, Tier 2, or Tier 3. These tiers increase in complexity and require more detailed data as they progress from Tiers 1 to 3. Due to the lack of detail in animal population characteristics, the Tier 1 approach was used to determine emissions from enteric fermentation. The steps taken to calculate the emissions are detailed below:

Step 1: Determine Animal Population Data

Animal population data for the years 2000[2] and 2006[3] for the County of Albemarle were determined using the United States Department of Interior's Census of Agriculture[4]. The animal populations were broken down into: dairy cattle[5], non-dairy cattle, swine[6], horses, sheep, and goats.

[1] Act of belching.
[2] The census is taken at 5-year intervals: 1992, 1997, 2002, 2007, so on. The average of the 1997 and 2002 population data was calculated to estimate the size of the animal populations for 2000, our baseline year.
[3] 2007 animal population data was assumed to be roughly equivalent to the 2006 animal data.
[4] which was accessed online at: http://www.agcensus.usda.gov/
[5] Also known as milk cows
[6] Also known as hogs and pigs

Step 2: Determine Emission Factors
Due to lack of state-specific emission factors, countrywide emission factors provided by the IPCC were used.

Step 3: Calculate Emissions for Each Livestock Category
The emissions for each livestock category were calculated by using Equation 10.19 in the IPCC methodology:

EQUATION 10.19
ENTERIC FERMENTATION EMISSIONS FROM A LIVESTOCK CATEGORY

$$Emissions = EF_{(T)} * (N_{(T)})$$

Where:
Emissions = Methane emissions from Enteric Fermentation, Gg C H_4 yr^{-1}
$EF_{(T)}$ = Emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1}
$N_{(T)}$ = The number of head of livestock species / category T in the county (in millions)
T = Species/category of livestock (e.g., swine or dairy cattle)

Step 4: Calculate Total Emissions
To estimate total emission, the emissions for each livestock category from above were summed together.

EQUATION 10.20
TOTAL EMISSIONS FROM LIVESTOCK ENTERIC FERMENTATION

$$Total\ CH_{4,Enteric} = \sum E_i$$

Where:
Total $CH_{4Enteric}$ = Total methane emissions from Enteric Fermentation, Gg CH_4 yr^{-1}
E_i = Emissions for the *i*th livestock categories and subcategories

Table 2 below summarizes the enteric fermentation emissions from livestock contributing to the County of Albemarle's baseline emissions.

Table 5. Methane emissions from enteric fermentation of livestock broken down by categories.

Animal Type	**2000 Estimated Census**	**Emissions Factor (Kg CH_4/head/yr)**	**Enteric Emissions (Gg CH_4/yr)**
Milk Cows	658	121	0.079618
Non-dairy cattle	26283	53	1.392999
Hogs and pigs aka swine	235	1.5	0.0003525
Horses and ponies	2669	18	0.048033
Sheep and lambs	2013	8	0.0161
Goats	240	5	0.0011975
Total CH4 Enteric Fermentation Emissions			1.5383

Manure Management

Background

Decomposition of manure[7] under anaerobic[8] conditions, during storage and treatment, produces CH_4. These anaerobic conditions occur most readily when large numbers of animals are managed in a confined area (e.g., beef feedlots, swine farms, etc.), and where manure is disposed of in liquid-based systems. This section of the methodology accounts for CH_4 emissions related to manure handling and storage. Similar to enteric fermentation emissions, there are three tiers or approaches to accounting methane emissions from manure management practices. Unlike the previous agricultural activity, there were sufficient data available to use the Tier 2 approach in calculating these emissions. This new approach required the calculation of County of Albemarle specific emission factors through a modified version of Step 2 from the previous section. Thus, a combination of IPCC equations and Virginia-specific emission factors were used to tally methane emissions from manure management.

Methodology

Tier 2

A more complex method for estimating CH4 emissions from manure management should be used where a particular livestock species/category represents a significant share of a country's emissions. This method requires detailed information on animal characteristics and manure management practices, which is used to develop emission factors specific to the conditions of the country (IPCC 2006).

Step 1: Determine Animal Population Data

Animal population data for the years 2000[9] and 2006[10] for the County of Albemarle were determined using the United States Department of Interior's Census of Agriculture[11]. The animal populations were broken down into: dairy cattle[12], non-dairy cattle, swine[13], horses, sheep, and goats.

Step 2: Calculate Emission Factors for Each Livestock Category

Equation 10.23 in the IPCC methodology was used to calculate specific manure management methane emission factors for the County of Albemarle. Due to incompatible units, default VS values provided by IPCC were used. US-specific B_o values were used as listed in the US Greenhouse Gas Emissions & Sinks (EPA 2008). Virginia-specific manure distribution and

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[7] 'Manure' means both dung and urine (solid and liquid) produced by livestock (IPCC).
[8] In the absence of oxygen
[9] The census is taken at 5-year intervals: 1992, 1997, 2002, 2007, so on. The average of the 1997 and 2002 population data was calculated to estimate the size of the animal populations for 2000, our baseline year.
[10] 2007 animal population data was assumed to be roughly equivalent to the 2006 animal data.
[11] which was accessed online at: http://www.agcensus.usda.gov/
[12] Also known as milk cows
[13] Also known as hogs and pigs

corresponding methane conversion factors listed in the EPA's report were used to determine each manure management system's MS and MCF values.

EQUATION 10.23

METHANE EMISSION FACTOR FROM MANURE MANAGEMENT

$$EF_{(T)}=(VS_{(T)}*365)*[B_{o(T)}*0.67\ kg/m^3*\sum MCF_{S,k}/100*MS_{(T,S,k)}$$

Where:

$EF_{(T)}$ = Annual methane emission factor for livestock category T, kg CH_4/animal/year

$VS_{(T)}$ = Daily volatile solid excreted by livestock category T, kg dry matter/animal/day

365 = Basis for calculating annual VS production, days/yr

$B_{o(T)}$ = Maximum methane producing capacity for manure produced by livestock category T, m^3 CH_4/kg of VS excreted

0.67 kg/m^3 = Conversion factor of m^3 CH_4 to kilograms CH_4

$\sum MCF_{S,k}$= Methane conversion factors for each manure management system S by climate region k, %

$MS_{(T,S,k)}$ = Fraction of livestock category T's manure handled using manure management system S in climate region k, dimensionless

Step 3: Calculate Emissions for Each Livestock Category

Each livestock category emissions factors were multiplied by their corresponding population sizes to estimate subcategory emissions. Refer to Equation 10.22a below and in the IPCC methodology:

EQUATION 10.22a

MANURE MANAGEMENT METHANE EMISSIONS FROM A LIVESTOCK CATEGORY

$$Emissions = EF_{(T)}*(N_{(T)})$$

Where:

Emissions = Methane emissions from Enteric Fermentation, Gg CH_4 yr^{-1}

$EF_{(T)}$ = Emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1}

$N_{(T)}$ = The number of head of livestock species / category T in the county (in millions)

T = Species/category of livestock (e.g., swine or dairy cattle)

Step 4: Calculate Total Emissions

To estimate total emissions, the emissions for each livestock category from above were summed together.

EQUATION 10.22b

TOTAL EMISSIONS FROM LIVESTOCK MANURE MANAGEMENT

$$Total\ CH_{4,Manure} = \sum E_i/10^6$$

Where:

Total $CH_{4,Manure}$ = Total methane emissions from Enteric Fermentation, Gg CH_4 yr^{-1}

E_i = Emissions for the *i*th livestock categories and subcategories

10^6 = Conversion factor for methane emissions from kg to Gg.

Table 3 below summarizes methane emissions from manure management systems that contributed to the County of Albemarle's baseline emissions.

Table 6. Methane emissions from manure management of livestock broken down by categories.

Animal Type	**2000 Estimated Census**	**Emissions Factor (Kg CH_4/head/yr)**	**Methane Emissions (Gg CH_4/yr)**
Milk Cows	654.6	21.37738716	0.013993638
Non-dairy cattle	25443.2	1.892817	0.048159321
Hogs and pigs aka marketing swine	208.2	16.49339107	0.003433924
Horses and ponies	2686	0.085947098	0.000230888
Sheep and lambs	2061	0.0176076	3.62857E-05
Goats	215	0.006236025	1.33825E-06
Total CH_4 Manure Management Emissions			0.065855395

*Agricultural activities such as **rice cultivation** and **field burning of agricultural field residues** are not widely practiced in the County of Albemarle and thus, were not included in the calculations of baseline emissions.*

N_2O Emissions

> ***Agricultural Soil Management***
> *Due to lack of detailed information on the types of fertilizers and the locations of their applications within the County of Albemarle, N_2O emissions due to agricultural soil management were not calculated.*

Manure Management

Nitrous oxide emissions from manure management can be emitted through both direct and indirect measures. These two methods are further explained below.

Direct Emissions

Background

Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. N_2O emissions from manure during storage and treatment depend on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. Nitrification (the oxidation of ammonia nitrogen to nitrate nitrogen) is a necessary prerequisite for the emission of N_2O from stored animal manures. Nitrification is likely to occur in stored animal manures provided there is a sufficient supply of oxygen.

Methodology

Step 1: Determine Animal Population Data

Animal population data for the years 2000[14] and 2006[15] for the County of Albemarle were determined using the United States Department of Interior's Census of Agriculture[16]. The animal populations were broken down into: dairy cattle[17], non-dairy cattle, swine[18], horses, sheep, and goats.

Step 2: Determine Emission Factors

Due to lack of state-specific emission factors, countrywide emission factors provided by the IPCC were used.

Step 3: Calculate Emissions for Each Livestock Category

Each livestock category's emissions factors were multiplied by their corresponding population sizes and average nitrogen excretion rates to estimate subcategory emissions. Equation 10.25a in the IPCC methodology was used to calculate specific manure management N_2O emission factors for the County of Albemarle. Virginia-specific manure distribution values and nitrogen

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[14] The census is taken at 5-year intervals: 1992, 1997, 2002, 2007, so on. The average of the 1997 and 2002 population data was calculated to estimate the size of the animal populations for 2000, our baseline year.
[15] 2007 animal population data was assumed to be roughly equivalent to the 2006 animal data.
[16] which was accessed online at: http://www.agcensus.usda.gov/
[17] Also known as milk cows
[18] Also known as hogs and pigs

excretion rates listed in the EPA's annual US Greenhouse Gas Emissions & Sinks were used to determine each manure management system's MS and livestock's Nex values.

EQUATION 10.25a
DIRECT NITROUS OXIDE EMISSION FACTOR FROM MANURE MANAGEMENT

$$E_{(mm)}=\sum(N_{(T)}*Nex_{(T)}*MS_{(T,S)})*EF_{(S)}$$

Where:

$E_{(mm)}$ = Direct N_2O emission from manure management, kg N_2O yr^{-1}
$N_{(T)}$ = Number of head of livestock species/category T in the County
$Nex_{(T)}$ = Annual average N excretion per head of species/category T in the country, kg N/animal/year
$MS_{(T,S)}$ = Fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless
$EF_{(S)}$ = Emissions factor for direct N_2O emissions from manure management system S in the country, kg N_2O-N/kg N in manure management system S

Step 4: Calculate Total Emissions
To estimate total emissions, the emissions for each livestock category from above were summed together. The conversion factor, 10^6, converts methane emissions from kilograms to gigrams (Gg).

EQUATION 10.25b
TOTAL EMISSIONS FROM LIVESTOCK MANURE MANAGEMENT

$$N_2O_{D(mm)} = \sum E_i*44/28$$

Where:

$N_2O_{D(mm)}$ = Total nitrous oxide direct emissions from manure management, kg N_2O yr^{-1}
E_i = Emissions for the *i*th livestock categories and subcategories
44/28 = Conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions

Indirect Emissions

Background

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NO_x. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature. Simple forms of organic nitrogen such as urea (mammals) and uric acid (poultry) are rapidly mineralized to ammonia nitrogen, which is highly volatile and easily diffused into the surrounding air (Asman *et al.*, 1998; Monteny and Erisman, 1998). Nitrogen losses begin at the point of excretion in houses and other animal production areas (e.g., milk parlors) and continue through on-site management in storage and treatment systems (i.e., manure management systems). Nitrogen is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots and where animals are grazing in pastures.

Methodology

Step 1: Determine Animal Population Data

Animal population data for the years 2000[19] and 2006[20] for the County of Albemarle were determined using the United States Department of Interior's Census of Agriculture[21]. The animal populations were broken down into: dairy cattle[22], non-dairy cattle, swine[23], horses, sheep, and goats.

Step 2: Determine Emission Factors

Due to lack of state-specific emission factors, countrywide emission factors provided by the IPCC were used.

Step 3: Calculate Emissions for Each Livestock Category

Each livestock category emissions factors were multiplied by their corresponding population sizes and average nitrogen excretion rates to estimate subcategory emissions. These values were then summed across each livestock category, T and each manure management system, S. Equation 10.28 in the IPCC methodology was used to calculate specific manure management N_2O emission factors for the County of Albemarle. Virginia-specific manure distribution values and nitrogen excretion rates listed in the EPA's annual US Greenhouse Gas Emissions & Sinks were used to determine each manure management system's MS and livestock's Nex values. IPCC default values listed in Table 10.23 for percentage of managed manure nitrogen losses for each livestock category were used ($Frac_{leach,MS}$).

EQUATION 10.28

N LOSSES DUE TO LEACHING FROM MANURE MANAGEMENT SYSTEMS

$$N_{leaching\text{-}MMS}=\sum_S[\sum_T[(N_{(T)}*Nex_{(T)}*MS_{(T,S)})*(Frac_{leach,MS}/100)_{(T,S)}]]$$

Where:

$N_{leaching\text{-}MMS}$= Amount of manure nitrogen that leached from manure management systems, kg N/yr

$N_{(T)}$ = Number of head of livestock species/category T in the County

$Nex_{(T)}$ = Annual average N excretion per head of species/category T in the country, kg N/animal/year

$MS_{(T,S)}$ = Fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless

[19] The census is taken at 5-year intervals: 1992, 1997, 2002, 2007, so on. The average of the 1997 and 2002 population data was calculated to estimate the size of the animal populations for 2000, our baseline year.

[20] 2007 animal population data was assumed to be roughly equivalent to the 2006 animal data.

[21] which was accessed online at: http://www.agcensus.usda.gov/

[22] Also known as milk cows

[23] Also known as hogs and pigs

$(Frac_{leach,MS}/100)_{(T,S)}$ = Percent of managed manure nitrogen losses for livestock category T due to runoff and leaching during solid and liquid storage of manure (typical range 1-20%)

Step 4: Calculate Total Emissions
Total indirect N_2O emissions from leaching and runoff of nitrogen were estimated using Equation 10.29 from the IPCC methodology. The default EF value listed was used.

EQUATION 10.29
INDIRECT N_2O EMISSIONS DUE TO LEACHING FROM MANURE MANAGEMENT

$$N_2O_{L(mm)} = N_{leaching\text{-}MMS} * EF * 44/28$$

Where:
$N_2O_{L(mm)}$ = Indirect N_2O emissions due to leaching and runoff from Manure Management in the county, kg N_2O/yr
$N_{leaching\text{-}MMS}$= Amount of manure nitrogen that leached from manure management systems, kg N/yr
EF = Emission factor for N_2O emissions from nitrogen leaching and runoff, kg N_2O-N/kg N leached and runoff; default value 0.0075 kg N_2O-N (kg N leaching/runoff)$^{-1}$
44/28 = Conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions

Table 4 below summarizes nitrous oxide emissions from manure management systems that contributed to the County of Albemarle's baseline emissions. The sum of direct and indirect emissions yields total N_2O emissions from manure management in the County of Albemarle.

Table 7. Nitrous oxide emissions from manure management of livestock broken down by categories.

Animal Type	Direct N_2O Emissions (kg N_2O/yr)	Indirect N_2O Emissions	N_2O Emissions (kg N_2O/yr)
Milk Cows	0.470713509	0.528873783	0.999587292
Non-dairy cattle	248.5091865	37.18341943	285.6926059
Hogs and pigs aka marketing swine	0.23634864	0.61938459	0.85573323
Horses and ponies	0	0.781404348	0.781404348
Sheep and lambs	0	0.781404348	0.781404348
Goats	0	0.781404348	0.781404348
Total N_2O Manure Management Emissions			289.8921395

APPENDIX B: EMPLOYEE COMMUTE METHODOLOGY

Background

The employee commute sector calculates emissions associated with travel to and from the work by employees of the government. The employee sector has the same inputs as other transportation-related sectors (i.e., vehicle fleet). The number of total miles traveled by government employees for work each year was calculated for input into the software.

Methodology

Many institutions have conducted surveys amongst a select portion of their employees to estimate the number of miles traveled by all employees. However, many County of Albemarle employees travel varying distances to work; for example, the average distance traveled by a COB McIntire employee is not the same as the average distance traveled by a school teacher. So the County of Albemarle chose to use GIS software, instead, to better approximate employee commuting distance.

A list of employee's home addresses and corresponding work addresses was obtained from the Human Resources Department. Each employee was assigned a unique ID for reference rather than their names to maintain confidentiality.

Once data was obtained, each address was assigned its geographic x-y coordinates through GIS and mapped. ince GIS recognizes only a limited range of abbreviations, certain addresses had to be modified for recognition by the software. For example, "T.J." was reentered as "Thomas Jefferson" in the database. Some addresses consisting of P.O. Box and route numbers were filtered out since GIS was unable to assign them to specific geographic coordinates. Employees' unique IDs were used to track the changes made to their addresses through the years.

The "Network Analyst" tool was used to calculate the shortest distance on roads for each home address to every potential work address. Every route except the listed home address and corresponding actual work address was then filtered out by Microsoft Access. The remaining entries yielded the number of miles traveled by each employee during a one-way trip to their workplace[24]. This number was then doubled to reflect a round-trip and multiplied by the number of workdays in a year: 230.

The average number of miles driven by an Albemarle County employee for work: 10 miles.

Certain employees worked at varying locations throughout the week. In these circumstances, the worst-case scenario or the furthest work address was chosen to best reflect their emissions.

[24] For some employees who no longer worked for the county, HR had updated their past home addresses to their current ones. Thus, certain routes yielded a daily commute of more than 100 miles for a single round-trip. To limit the effect of these addresses on total commute, we assumed that no County employee traveled more than 150 miles on any given day to/from their work place.

APPENDIX C: CORRECTIONS TO THE BASELINE

Background

Finding error with the prior calculation method for residential heating fuel use, we developed a new technique[25] for estimating associated eCO_2 emissions. The previous method, using Charlottesville gas data on natural gas consumption in the County and EIA data on total natural gas usage in the state of Virginia, found the proportion of natural gas consumption that Albemarle County accounted for in the state for both 2000 and 2006. This proportion of Albemarle consumption to VA state consumption for natural gas was assumed to be applicable to other fuel types, and Albemarle values were inferred from state values provided by EIA. It is easy to imagine the County using fuels in different relative amounts when compared to state-wide aggregate data. This inference method is likely flawed as there is a fair amount of conflicting data. For example, the Census household heating fuel data suggests that electricity is the most common heating method for the County, followed by natural gas, propane, and oil, whereas the old method places natural gas behind oil and propane.

Modified Methodology

Using data on fuel consumption and household numbers, we calculated a figure representing typical energy usage per household. We used the natural gas consumption by County residents in 2006 of 334,863 thousand cubic feet (Mcf), from Charlottesville gas data, and the 5,334 households using natural gas in 2006, from 2006 Census data. We assumed a one-to-one conversion factor between Mcf and MMBtu for natural gas. Dividing total natural gas consumption by the number of households using natural gas yields energy usage of 62.779 MMBtu per household[26].

Using this energy consumption per household figure coupled with the number of households using different fuel types from census data, we found the total energy consumption for each fuel. We assumed that, regardless of fuel type, households would have similar energy demands for heating (62.779 MMBtu). For example, in 2006 3,757 households used propane for heating; multiplying by 62.779 MMBtu/household yields 235,861 MMBtu. These energy consumption by fuel type figures were then input into the CACP software to determine eCO_2 emissions for each fuel. The sum of these emissions is the new value for residential emissions due to residential heating fuel consumption.

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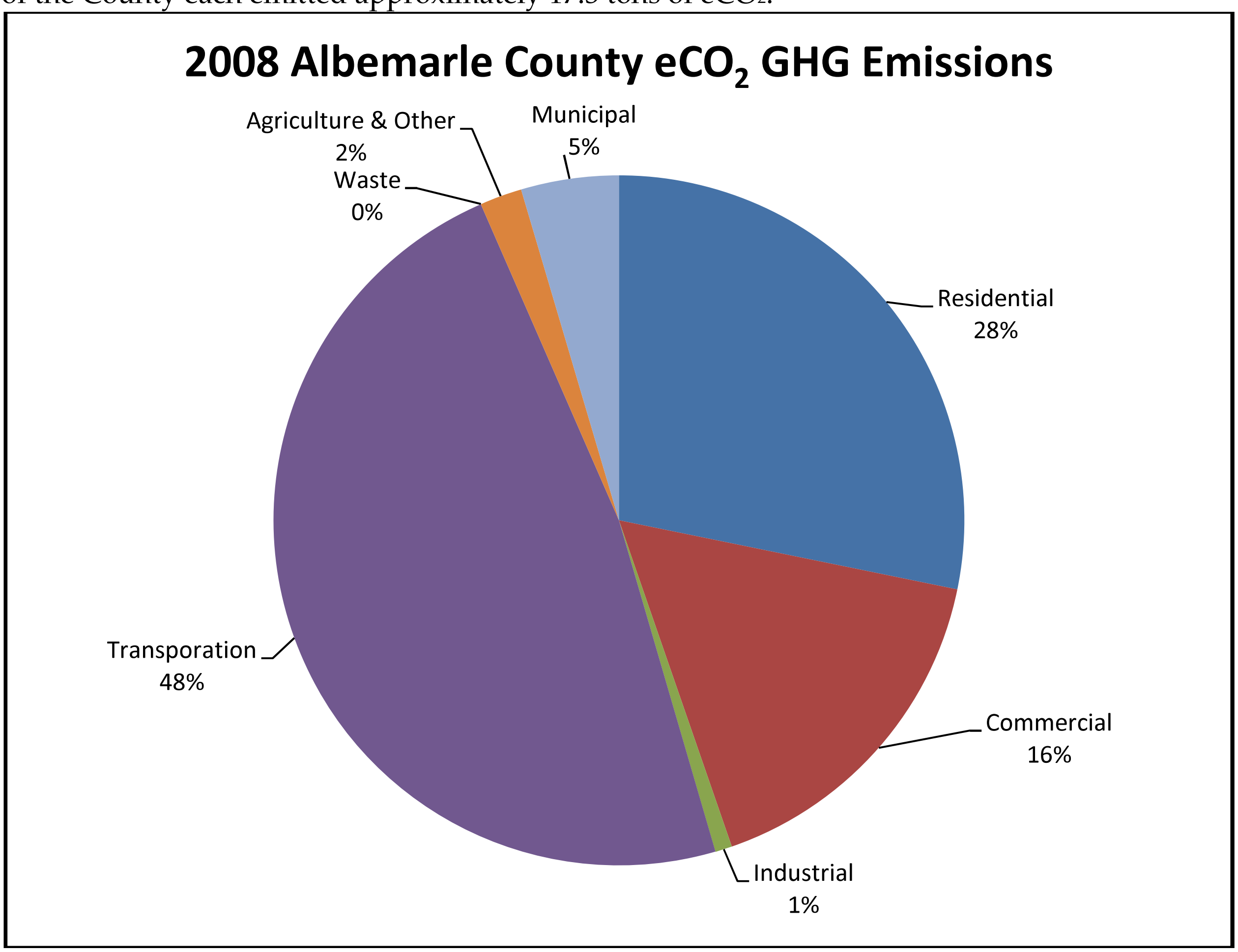
[25] Credit to Andrew Greene, Sustainability Planner in the Office of the Architect for the University of Virginia, for recognizing the error and developing the new calculation method

[26] For independent comparison, the EIA reports that in 2001 for the South Atlantic census region, residential natural gas use is 61.2 MMBtu per household (http://www.eia.doe.gov/emeu/recs/recs2001_ce/ce1-11c_so_region2001.html).

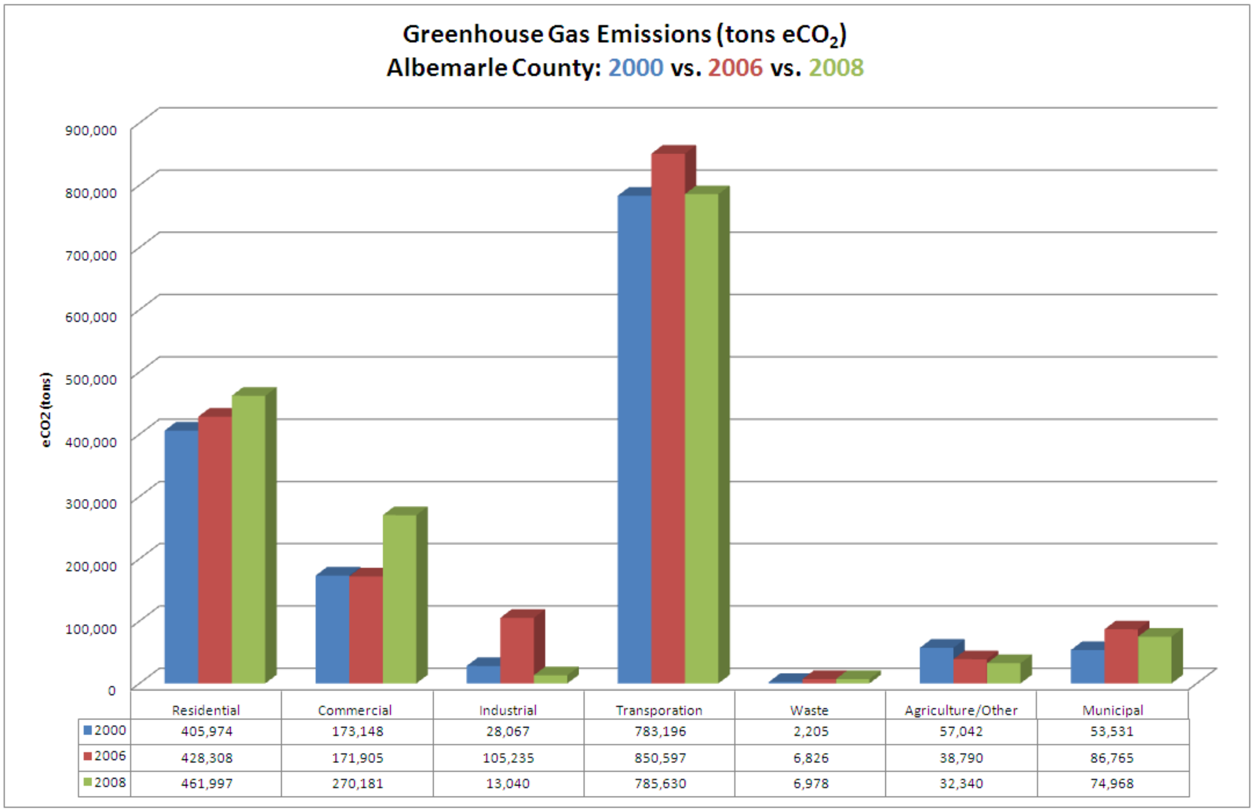
APPENDIX D: 2008 UPDATE

The 2000 baseline inventory was the first of the ICLEI milestones. Establishing a goal of 20% emission reductions by 2020 represented the second milestone. The County has been working collaboratively with the City of Charlottesville and the University of Virginia to develop the local climate action plan, a milestone nearing completion in 2010. The Steering Committee was established, and focus groups have been responsible for various elements of the plan including embodied energy, energy sourcing, energy and mobility, energy conservation, and carbon sequestration. The Steering Committee will ultimately issue a report outlining strategies that are particular to each entity, as well as those that present shared opportunities. Once these recommendations are in place, each participating entity will have to determine what is appropriate for the specifics of implementation.

The 2008 data was analyzed using the Clean Air and Climate Protection (CACP) software developed by ICLEI. According to the software, the County emitted a total of 1,645,134 tons of carbon dioxide equivalent (eCO_2) in the year 2008. Specific breakdowns across sectors (transportation, commercial, residential, etc.) are presented below. In 2008, the 94,908 residents of the County each emitted approximately 17.3 tons of eCO_2.



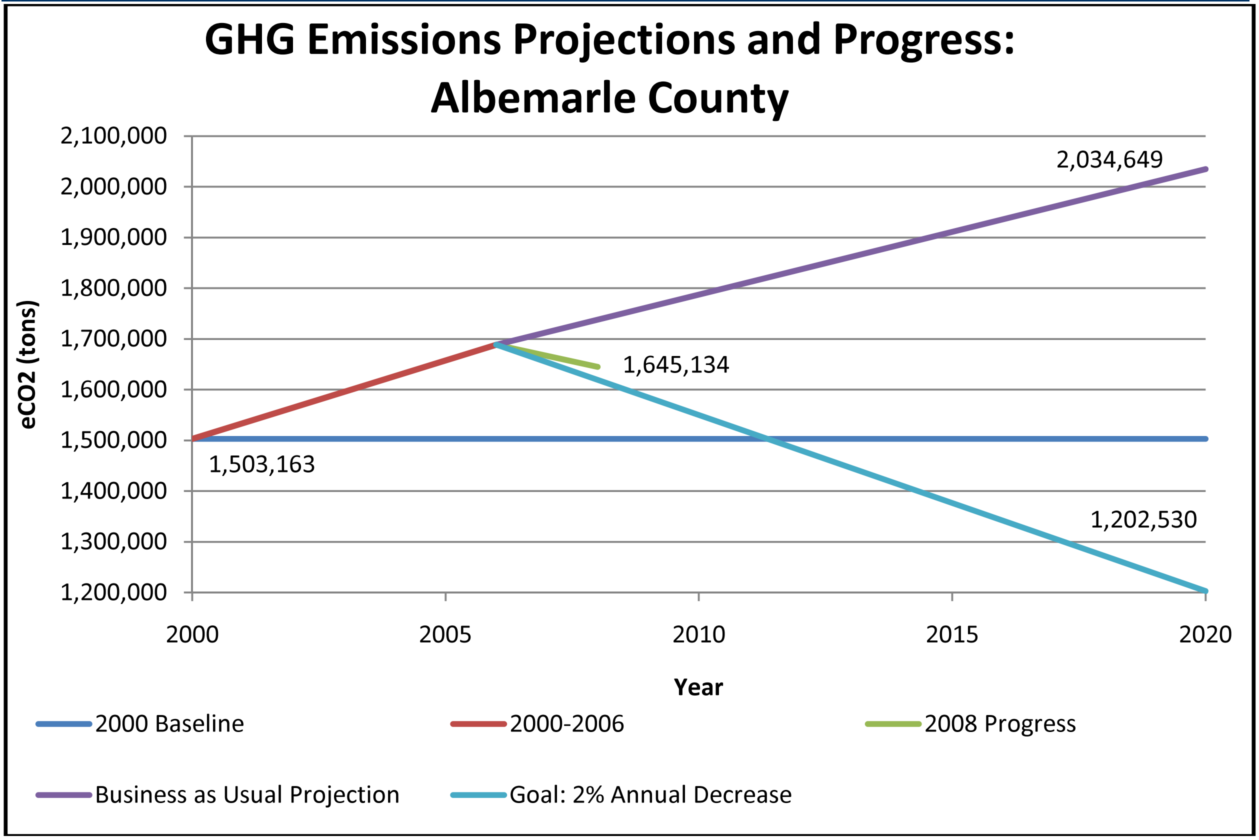
Emissions of carbon dioxide equivalents rose in the residential, commercial, and waste sectors between 2006 and 2008. The industrial, transportation, agricultural, and municipal sectors all showed decreases in emissions over this same time period. With regard to the 2000 baseline, residential, commercial, transportation, waste, and municipal sectors showed increases in eCO_2 emissions. The industrial sector shows lower emissions in 2008 than in 2000. In total, 2008 eCO_2 emissions represented 97% of 2006 emissions or 109% of baseline 2000 emissions.



	Residential	Commercial	Industrial	Transporation	Waste	Agriculture/Other	Municipal
2000	405,974	173,148	28,067	783,196	2,205	57,042	53,531
2006	428,308	171,905	105,235	850,597	6,826	38,790	86,765
2008	461,997	270,181	13,040	785,630	6,978	32,340	74,968

In adopting the *U.S. Cool Counties Climate Stabilization Declaration*, the County pledged to reduce emissions by 80% of 2000 baseline levels by 2050. This corresponds to an average decrease of 2% per year beginning in 2010. To meet this target, the County must reduce emissions by 20% from its baseline emissions, or to 1,202,530 tons of eCO_2 by 2020.

The CACP software forecasts projections up to the year 2020 for a business-as-usual scenario; that is, the model assumes that governments, businesses, and individuals will not take any actions specifically aimed to reduce greenhouse gas emissions. Under these assumptions, the projected emissions for 2020 are 2,034,649 eCO_2 tons. The figure below depicts the County's current real progress toward this goal compared to 2000 baseline levels, the business-as-usual projection, and an average 2% annual decrease from the 2000 baseline.


GHG Emissions Projections and Progress:
Albemarle County
eCO2 (tons)
2,100,000
2,000,000
1,900,000
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
2000
2005
2010
2015
2020
Year
2,034,649
1,645,134
1,503,163
1,202,530
2000 Baseline
2000-2006
2008 Progress
Business as Usual Projection
Goal: 2% Annual Decrease

Appendix E: Board of Supervisors Resolution

RESOLUTION TO SUPPORT THE COUNTY, CITY AND UNIVERSITY WORKING COLLABORATIVELY TO ADDRESS ENERGY EFFICIENCY AND CLIMATE CHANGE

WHEREAS, addressing energy efficiency and climate change will promote a cleaner environment, a more prosperous economy and a higher quality of life; and

WHEREAS, the County of Albemarle, City of Charlottesville and University of Virginia have committed to promoting energy efficiency and climate change programs within their respective organizations; and

WHEREAS, the County, City and University desire to work collaboratively to promote energy efficiency and address climate change goals for the community;

NOW, THEREFORE, BE IT RESOLVED, that the Albemarle County Board of Supervisors supports the County, City and University working cooperatively to discuss energy and climate change opportunities, including collaborating on developing a joint proposal for the Southeastern Energy Efficiency Alliance grant; and

FURTHER RESOLVED to appoint a member of the Board of Supervisors and a member of the Planning Commission, to be the County's representatives in such discussions and working groups.

I, Ella W. Jordan, do hereby certify that the foregoing writing is a true and correct copy of a Resolution duly adopted by the Board of Supervisors of Albemarle County by a vote of six to zero, as recorded below, at a meeting held on January 14, 2009.

Clerk, Board of County Supervisors

	Aye	Nay
Mr. Boyd	Y	
Mr. Dorrier	Y	
Ms. Mallek	Y	
Mr. Rooker	Y	
Mr. Slutzky	Y	
Ms. Thomas	Y	