ATTACHMENT A

A RESOLUTION ACCEPTING THE CAPSTONE GREENHOUSE GAS INVENTORY REPORT AS PREPARED BY STUDENTS FROM UNC'S INSTITUTE FOR THE ENVIRONMENT

Draft Resolution No. 104/2010-11

WHEREAS, the Board of Aldermen has adopted a resolution to take responsibility for the Town's Greenhouse Gas Emissions;

WHEREAS, The Town is committed to doing its part in conjunction with the county, the state and the country to make progress toward addressing the causes of climate change, and;

WHEREAS, Town Staff has secured the generous help of students from UNC's Institute for the Environment to assist with developing a baseline Greenhouse Gas Inventory;

NOW, THEREFORE BE IT RESOLVED that the Carrboro Board of Aldermen hereby accept the Town of Carrboro Greenhouse Gas Inventory Report.

Section 3. The Board of Aldermen authorizes the Town Manager to execute a contract for services with The Dispute Settlement Center, Inc., for an amount not to exceed $3,800.

Section 4. The Board of Aldermen approves the draft agenda for the 2010 Planning Retreat, amended to reduce the overview and status of Vision 2020 by 30 minutes.

Section 5. This resolution shall become effective upon adoption.

The foregoing resolution having been submitted to a vote received the following vote and was duly adopted this 8th day of December 2009:

Ayes: Dan Coleman, Sammy Slade, Lydia Lavelle, Mark Chilton, Joal Hall Broun, Jacquelyn Gist, Randee Haven-O'Donnell

Noes: None

Absent or Excused: None

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A RESOLUTION TO TAKE RESPONSIBILITY IN A SOCIALLY JUST MANNER FOR CARRBORO'S PORTION OF CO2 IN THE ATMOSPHERE; TOWARD GETTING THE ATOSPHERE BACK TO A SAFE LEVEL BELOW 350 PPM OF C02

The following resolution was introduced by Alderman Sammy Slade and duly seconded by Alderman Randee Haven-O'Donnell.

A RESOLUTION TO TAKE RESPONSIBILITY IN A SOCIALLY JUST MANNER FOR CARRBORO'S PORTION OF CO2 IN THE ATMOSPHERE; TOWARD GETTING THE ATMOSPHERE BACK TO A SAFE LEVEL BELOW 350 ppm OF CO2
Resolution No. 78/2009-10

WHEREAS, if humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO2 will need to be reduced from its current 385 ppm to at most 350 ppm, but likely less than; and

WHEREAS, to achieve the 350 ppm target, scientists have calculated that the major industrialized nations need to cut their CO2 emissions by 40% from 1990 levels by 2020; and

WHEREAS, the Copenhagen Climate Change Summit (December 7-18) is the UN meeting and deadline for preventing dangerous global warming; and

WHEREAS, the Obama administration in Copenhagen is expected to offer a promise that the equivalent of 4% CO2 emissions will be cut from 1990 levels by 2020; and

WHEREAS, the climate bill passed by the U.S. House of Representatives, as well as legislation currently pending in the Senate, would eliminate EPA's authority under the Clean Air Act to designate greenhouse gases as criteria air pollutants and to set a cap on such emissions; and

WHEREAS, International and National scales of governance are failing to be responsible and to take the necessary action to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted.

NOW, THEREFORE BE IT RESOLVED BY THE BOARD OF ALDERMEN OF THE TOWN OF CARRBORO:

Section 1. The town of Carrboro commits to taking responsibility in a socially just manner for its share of CO2 emissions in the atmosphere.

Section 2. The Town of Carrboro will seek, and will facilitate the community at large, to cut CO2 emissions by its proportion of the amount which is required to stabilize the climate back to less than 350 ppm of CO2 in the atmosphere in time for a 90% probability for success as defined by the most up to date scientific consensus.

Section 3. This resolution shall be referred to staff for further evaluation of what measures will be needed to achieve this target for the Town of Carrboro and the community at large.

Section 4. The Town of Carrboro will make a formal request to the County Commissioners, Representative Verla Insko, Representative Bill Faison, Speaker of the House Joe Hackney, N.C. Senator Ellie Kinnaird, Congressman David Price, U.S. Senator Kay Hagan, U.S. Senator Richard Burr, and President Barack Obama, to take any and all necessary actions required to facilitate for Carrboro the achievement of the responsible ambition to combat Climate Change in time for a 90% probability for success as defined by the most up to date scientific consensus.

Section 5. This resolution shall become effective upon adoption.

The foregoing resolution having been submitted to a vote received the following vote and was duly adopted this 8th day of December 2009:

Ayes: Dan Coleman, Sammy Slade, Lydia Lavelle, Mark Chilton, Joal Hall Broun, Jacquelyn Gist, Randee Haven-O'Donnell

Noes: None

Absent or Excused: None

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APPOINTMENT TO SAFE ROUTES TO SCHOOL ACTION PLAN TEAM

MOTION WAS MADE BY JOAL HALL BROUN AND SECONDED BY RANDEE HAVEN-O'DONNELL TO APPOINT MAYOR CHILTON AS THE BOARD OF ALDERMEN'S REPRESENTATIVE ON THE SAFE ROUTES TO SCHOOL ACTION PLAN TEAM. VOTE: AFFIRMATIVE ALL

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MOTION WAS MADE BY RANDEE HAVEN-O'DONNELL AND SECONDED BY JOAL HALL BROUN TO ADJOURN TO CLOSED SESSION TO DISCUSS A PERSONNEL MATTER AT 11:20 P.M. VOTE: AFFIRMATIVE ALL

MOTION WAS MAE BY JOAL HALL BROUN AND SECONDED BY JACQUELYN GIST TO ADJOURN THE MEETING AT 11:26 P.M. VOTE: AFFIRMATIVE ALL

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Town of Carrboro Baseline Greenhouse Gas Emissions Inventory

Evaluating the 2009 Carbon Footprint of the "Paris of the Piedmont"

Produced by:

Spring 2011 Greenhouse Gas Emissions Inventory Capstone Team

Melissa Auton, Vanessa Fixmer-Oraiz, Holly Kuestner, Lauren Mendel, Matt Scruggs, Brian Vanderjeugdt, Jayce Walker, and Maddy Young

UNC INSTITUTE FOR THE ENVIRONMENT

TOWN OF CARRBORO March 3, 1911 NORTH CAROLINA

Table of Contents

List of Acronyms and Terms

AVMT	Annual Vehicle Miles Traveled
CACP	Clean Air Climate Protection Software
CAMPO	Capital Area Metropolitan Planning Organization
CFL	Compact Fluorescent Light Bulb
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
COP	Conference of the Parties
DOE	Department of Energy
DVMT	Daily Vehicle Miles Traveled
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GWP	Global Warming Potential
EPA	Environmental Protection Agency
ICLEI	ICLEI – Local Governments for Sustainability
IPCC	Intergovernmental Panel on Climate Change
kGal	Kilogallon
kWh	Kilowatt-hour
LED	Light-Emitting Diode
LGOP	Local Government Operations Protocol
LP	Liquefied Petroleum
MTCDE	Metric Ton of Carbon Dioxide Equivalent
N_2O	Nitrous Oxide
NCDOT	North Carolina Department of Transportation
NCDWM	North Carolina Division of Waste Management
OCSW	Orange County Solid Waste
OWASA	Orange Water and Sewer Authority
PAYT	Pay As You Throw
PEMC	Piedmont Electric Membership Corporation
PSNC	Public Service Company of North Carolina
ppm	Parts per million
tonne	Metric ton, 1000 kilograms (kg)
VMT	Vehicle Miles Traveled
WISE	Worthwhile Investments Save Energy

Town of Carrboro is the sum of the community and the public sector
Public Sector includes municipal operations, schools and water
Municipality includes local government operations
Community includes residential, commercial, industrial use, and automobile transportation.

Executive Summary

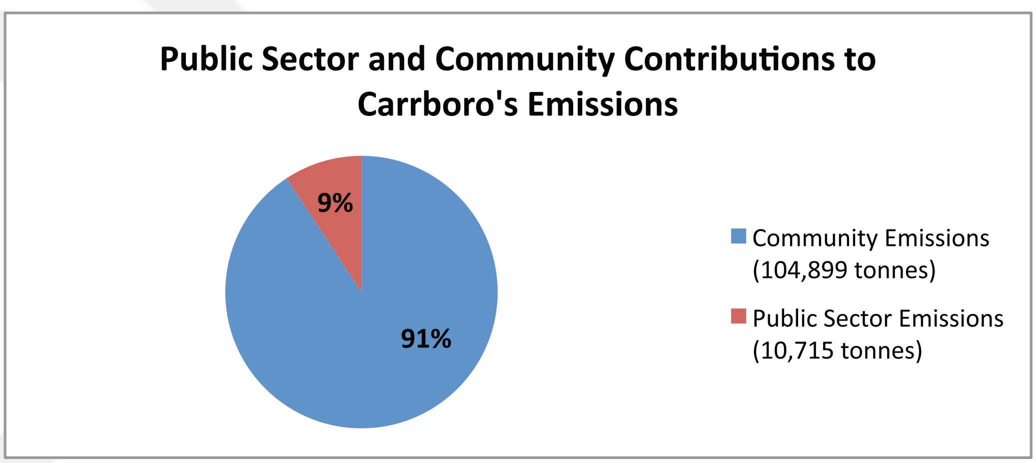
One of the most pressing problems facing humanity is global climate change. Anthropogenic greenhouse gas emissions are driving climate disruption at an unprecedented rate. Without aggressive mitigation efforts, the impacts likely will include the flooding of coasts, increasingly severe storms and droughts, tropical pest migrations poleward, and public health problems from heat waves and poor air quality.[i]

Communities have begun to act to reduce their GHG emissions, and in order to assess their progress over time, they often begin by conducting baseline GHG emissions inventories. A baseline inventory outlines the sources of GHG emissions in the community and serves as a starting point from which goals can be set for future emissions reductions. Subsequent GHG emissions inventories should then be made at regular intervals to measure the efficacy of energy-saving initiatives.

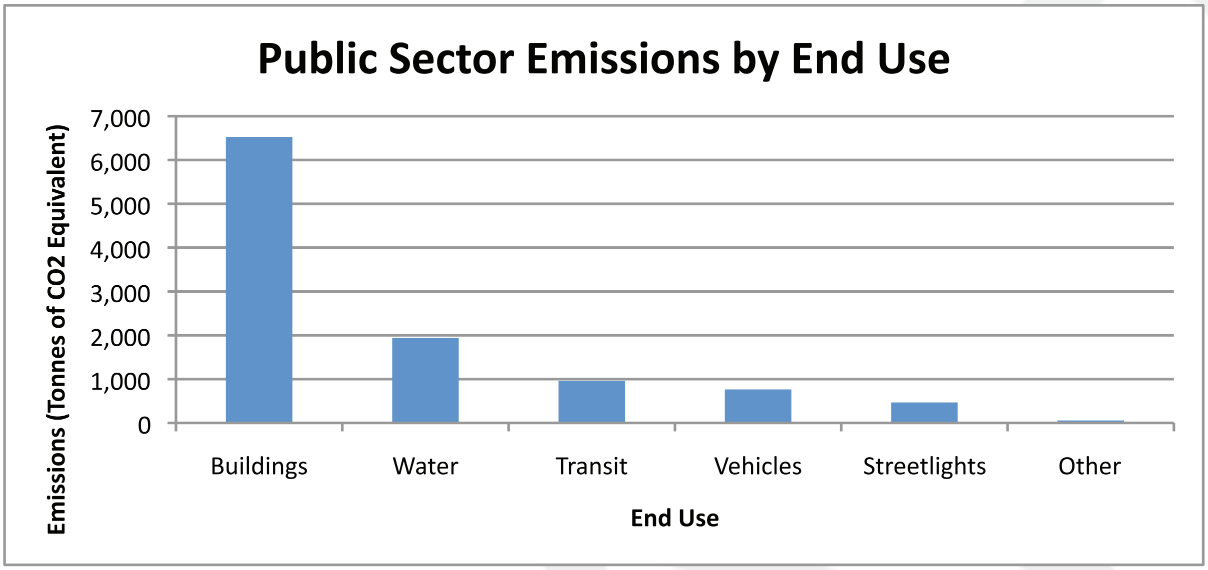
At the request of the Town of Carrboro, a 2009 baseline emissions inventory was completed by our team, the spring 2011 Greenhouse Gas Emissions Inventory Capstone team under UNC's Institute for the Environment. Members of the capstone team include Melissa Auton, Vanessa Fixmer-Oraiz, Holly Kuestner, Lauren Mendel, Matt Scruggs, Brian Vanderjeugdt, Jayce Walker, and Maddy Young. This inventory updates the previous Orange County inventory, and provides greater specificity for Carrboro.

Building the inventory involved retrieving and synthesizing data from a variety of sources. The emissions baseline data was analyzed using ICLEI's Clean Air & Climate Protection (CACP). In some cases the data were not complete, and we made approximations to compensate.

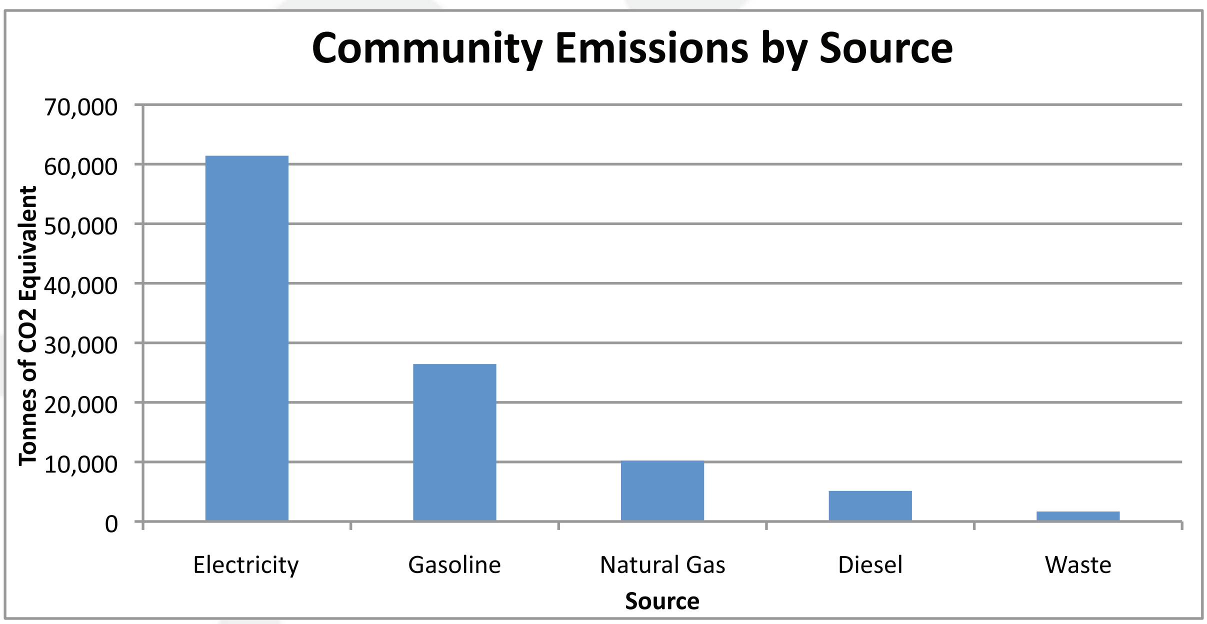
According to the baseline analysis, the Town of Carrboro emitted 115,614 metric tons of carbon dioxide equivalent (also tonnes of CO_2 equivalent) in calendar year 2009. Approximately 9% of these emissions were attributed to the public sector, which includes local government operations, schools, and water. The remaining 91% of emissions are attributed to the community, which includes residential, commercial, and industrial use.



For both the public sector and the community as a whole, the majority of GHG emissions were related to energy use in buildings.



The carbon footprint of electricity consumption was significantly higher than that of any other service or good. Natural gas and gasoline and diesel fuel for ground transportation were also significant.



GHGs emission sources are divided into three "Scopes" for the purposes of carbon accounting. The Scopes categorize emissions sources by level of immediacy. Scope 1 emissions are direct emissions from stationary and mobile fuel combustion that happens inside of the town limits. For example, auto emissions and emissions from local natural gas consumption are considered Scope 1. Scope 2 emissions are indirect emissions from acquired energy such as electricity, heat, steam and chilled water. The emissions are not actually occurring in Carrboro's town limits, but are caused directly by Carrboro's demand. Finally, emissions from producing goods and services that Carrboro residents or businesses used are considered Scope 3. There are embedded emissions associated with all goods (consider, for example, the energy that is required to manufacture a product). This study focused primarily on Scopes 1 and 2, though it does include solid waste, water, and schools, which are significant Scope 3 sources.

To put the Town of Carrboro's emissions level in perspective, when comparing its per capita municipal 2009 emissions level with that of Chapel Hill's per capita municipal 2005 emissions, the Town of Carrboro, which is three times smaller than Chapel Hill, emits nearly half as much CO2e. It is interesting to note that to offset these emissions for one year, the Town of Carrboro would need to plant and maintain a forest slightly less than eight times the land area of the town itself. Furthermore, 2009 emissions were approximately 18 times higher per person than if Carrboro residents only emitted CO_2 from breathing. This illustrates the effects of technology on community energy intensity.

Because the Town of Carrboro has indicated that any recommendations we can include in this report would be carefully considered, we have compiled a short list of suggestions based on the results of this report. While this is not an exhaustive list, it does focus on the sectors that had the most impact on the public sector and municipality carbon footprint; such as passive and active energy use in buildings. It is our hope that these recommendations and carbon equivalent comparisons will aid Carrboro in its efforts to enact and assess future steps that it utilizes to reduce its GHG emissions.

Introduction

This 2009 baseline emissions inventory for the Town of Carrboro was conducted by the spring 2011 Greenhouse Gas Emissions Inventory Capstone team under the University of North Carolina's Institute for the Environment. The team comprises eight upper-level undergraduates at the University of North Carolina, from a diverse range of academic fields, and with a variety of applied skills (GIS, environmental modeling, data collection and analysis, etc). Within the group there is a shared interest in sustainable practices relating to energy, resource consumption, and environmental quality.

Carrboro

Our project was executed on behalf of our client, the Town of Carrboro. Jeff Kleaveland, Planner and Zoning Development Specialist for the town, served as the liaison between our team and the town. The Town of Carrboro is a small town in the Piedmont region of North Carolina, with a population of about 20,000 as of 2010. It is known for a tradition of environmental awareness and stewardship, with such progressive policies as open-space protection and energy- and resource-conserving programs. In the past few years Carrboro has been proactively seeking ways to incorporate new sustainable principles into all its policies, including integrating a greenhouse gas emissions inventory into its responsibilities for the Planning Division. A 2005 GHG emissions inventory by ICLEI Energy Services covered Orange County, which included the Town of Carrboro, but did not break down the data by municipality.

Our Project

The process of GHG emissions auditing is evolving as more data become available and knowledge and practice accumulate. To build our greenhouse gas inventory for the Town of Carrboro, we utilized certain guiding resources. The first was a local government emissions protocol developed by The Climate Registry, California Air Resources Board, and the California Climate Action Registry, which directed us in methods of calculating greenhouse gas emissions. The aforementioned Orange County 2005 inventory also gave us an initial direction to begin our project. After meeting with representatives from the Town of Carrboro and consulting these resources, we drafted our own guiding documents. First was a workplan stating our initial goals, as set out by the Town of Carrboro and determined feasible by ourselves. The second was a timeline in which we scheduled target dates to begin and complete certain tasks. Both documents turned out to be fluid, changing with the availability of data, resources, and time.

The Town of Carrboro requested that we use the 350 movement as a guiding objective while conducting the greenhouse gas emission inventory. The 350 movement seeks to reduce global atmospheric carbon dioxide to below 350 parts per million, which some scientists, like Dr. James Hansen of the 350 movement, cite as a safe level of carbon dioxide concentration. This doctrine was the basis upon which we were to assess the Town of Carrboro's current rates of GHG emissions and determine the level of improvement required by the town to reach their stated goals.

We chose to limit our project in order to produce a sound baseline, on which future efforts can build, in the time available. The baseline inventory is for the 2009 calendar year. Only the area within 2009 city limits is included, and all unincorporated regions under the jurisdiction of the Town of Carrboro are excluded. To further define the scale of our project, the inventory is separated into emissions from the community and emissions from the public sector as a subset of the community as a whole.

Our work generated several related products. The first is the establishment of a 2009 baseline inventory for the Town of Carrboro, with a public sector baseline inventory for the year 2009 as a subset of the overall town emissions as well as defined scope of work. We have also analyzed Carrboro's contributions to greenhouse gas emissions, as requested by the Town of Carrboro. With this analysis we have provided recommendations for possible emission reduction measures. In addition, there are several items in relation to our project that have not been included in this report. Most notable is the presentation for the Board of Aldermen, Town Staff, and Advisory Board members of our findings. A workplan, timeline, and midterm report tracking our progress throughout each phase of the project are available. Finally the previous goal of developing a backcasting and forecasting report, as requested by the Town of Carrboro, is discussed in the Discussion portion of our report.

1 Background and Relevance

Greenhouse gas emissions inventories are becoming increasingly common and important as concerns over climate change deepen. The following sections provide an overview of the climate crisis and the impetus for developing inventories.

1.1 The Climate System

Without key gases in the Earth's atmosphere, incoming sunlight would reflect off of the Earth's surface and re-radiate into space, leaving the planet cold and inhospitable to life as we know it. Earth's biosphere—the collection of all living things on the planet—depends on greenhouse gases (GHGs) that trap heat in the lower atmosphere. When shortwave solar radiation strikes the Earth's surface and is reradiated into the atmosphere as longer-wavelength infrared rays, GHGs trap these infrared rays. This "greenhouse effect" significantly raises the average surface temperature of the planet, creating the conditions under which modern organisms have evolved.

GHGs cycle between the atmosphere and living organisms in natural processes that have maintained the climate system throughout geologic history. Photosynthetic organisms take up CO_2, water, and sunlight to synthesize carbohydrates for energy. This process releases oxygen into the environment, which some organisms (such as animals) breathe and use for respiration; this process, complimentary to photosynthesis, releases CO_2 as aerobic metabolism breaks down the carbohydrates consumed for energy. Approximately 20% of global carbon fixation is attributed to diatoms, which are tiny oceanic phytoplankton that support an extraordinary diversity of marine life. A portion of the carbon in the bodies of these phytoplankton sinks into the deep ocean, and over millions of years and under extreme pressure, this organic matter becomes oil.[ii] Coal is also formed by the compression of organic matter over geologic time periods, and a passing reference to the ancient nature of these materials appears in their name: fossil fuels. Because fossil fuels were formed from organic matter compressed over millions of years, they contain extraordinary quantities of carbon that were once present in the atmosphere. Burning them (chemically adding oxygen) releases the energy pent up in the chemical bonds, but it also releases the stored carbon, which takes the form of CO_2.

1.2 Climate Change

Humans are distorting the climate system by burning enormous volumes of these ancient carbon reserves, which is releasing large amounts of GHGs into the atmosphere at an unprecedented rate. The major GHGs increased by human activity are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). According to the latest report by the Intergovernmental Panel on Climate Change, an international consortium of scientists whose work earned a Nobel Prize in 2007, CO_2 concentrations have risen from 280 ppm before the Industrial Revolution in the mid-1700s to a 2005 level of 379 ppm.[iii] Methane and nitrous oxide concentrations have also risen, though emissions of these gases are more closely related to agriculture than to fossil fuel combustion. While they receive less media attention, methane and nitrous oxide are powerful GHGs; methane, for example, has a Global Warming Potential (GWP) of 21, meaning methane is 21 times more powerful as a GHG than an equal mass of CO_2. In North Carolina, key agricultural methane sources are the hog and poultry industries, because methane is produced as the manure decomposes.[iv] Methane is also produced in landfills as organic matter decomposes anaerobically, so urban areas directly produce this GHG as well.

GHGs have the potential to warm the planet beyond our capacity to adapt. As of 2005, global average temperatures had already increased by 0.7°C (1.3°F) since the Industrial Revolution.[v] We are likely already committed to a 1.5°C (2.7°F) increase that has not yet been felt, since much of the energy first goes into warming the oceans.[vi]

1.3 Projected Impacts of Climate Change

A key impact of climate change is sea level rise. This happens because of increased ocean water due to melting glaciers and ice sheets, and also because water expands as temperatures warm so the same quantity of water can fill a greater volume of space.[vii] Rising seas will inundate islands, coasts, and significant portions of low-lying countries such as Bangladesh. Further impacts include: increased severity of droughts and storms due to a disruption of the hydrological cycle; changing agricultural patterns; changes in species ranges and the extinction of those species unable to adapt or evolve quickly enough; changes in major ocean currents that could lead to serious impacts if tipping points are crossed; and the migration of tropical diseases poleward as the range of locales with suitably warm climates expands. Ocean acidification is also a concern, because approximately 30% of excess atmospheric CO_2 is absorbed by the oceans and takes the form of carbonic acid; this contributes to the decline of coral reefs and threatens

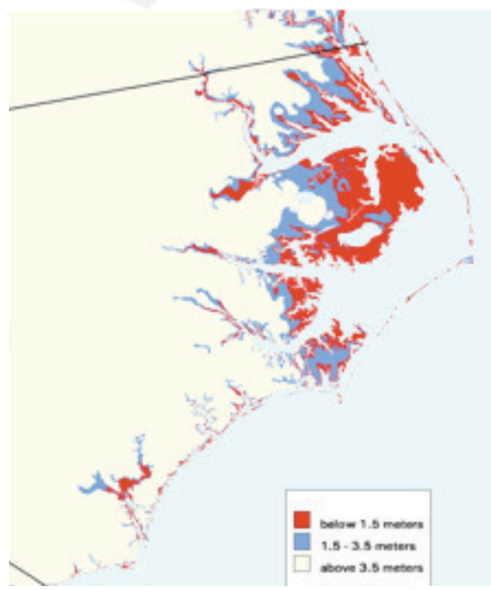


Figure 1. Elevations along the North Carolina coast. Regions in red are most vulnerable to sea level rise.

U.S. EPA. "Coastal Zones and Sea Level Rise - North Carolina." *US Environmental Protection Agency,* <http://www.epa.gov/climate change/effects/coastal/slrmaps_sa_nc.html>.

other marine life.[viii]

The effects of climate change will not be distributed evenly across the world, so it is also useful to consider the particular implications for North Carolina. The vulnerability of the Outer Banks and other coastal regions is a key concern. According to the EPA, sea level rise by 2100 along the Atlantic coast is likely to be around 0.55-0.60 m.[ix] The red areas in Figure 1 show parts of the North Carolina coast that are lower than 1.5 m above sea level. Parts of these areas are likely to flood by the end of the century unless emissions are massively curtailed.

According to a 2005 report by the Environmental Defense Fund, average temperatures in the southeastern United States may rise by 2.3°C-5.6°C (4.1°F-10°F) before 2100 if strong mitigation efforts are not realized. This could have significant air quality and health impacts because dangerous tropospheric ozone is produced on hot sunny days as nitrogen compounds in car exhaust fumes react with other airborne chemicals.[x] Furthermore, hurricanes derive their strength from the temperature of ocean surface waters, so the state may also experience more severe hurricanes.[xi] Because climate change is expected to interrupt the hydrologic cycle, there is concern in North Carolina about public health impacts from hog manure lagoons that may overflow in an era of more severe floods.[xii] Finally, the impacts on wildlife habitat will be significant, with coastal wetland ecosystems threatened by saltwater intrusion, flooding, and erosion.

While many of these impacts are grave, there is still time for communities to act to mitigate climate change by reducing GHG emissions.

1.4 Climate Policy

Because climate disruption is a global problem, countries have made attempts at cooperation through various conferences. The most high-profile of these meetings is the annual Conference of the Parties (COP). The Kyoto Protocol and the Copenhagen Accord are perhaps the two best-known international agreements resulting from the COP meetings. Countries signing on to the 1998 Kyoto Protocol agreed to reduce emissions levels to customized targets of at least 5% below 1990 levels by some point during the period from 2008-2012.[xiii] Reductions were expected to be achieved via a combination of renewable energy technology and policy, energy efficiency, land use changes, and emissions trading. However, there were weaknesses with the Kyoto Protocol, including: the United States did not ratify the treaty, though it is one of the biggest GHG emitters; countries in Eastern Europe emitted substantial GHGs in 1990 but their emissions plummeted dramatically as the economy collapsed with the fall of the USSR, so comparing their emissions to a 1990 baseline is considered unfair by many;[xiv] and the Protocol does not include developing countries.[xv]

Hopes were high for a more broadly encompassing, legally binding international treaty in Copenhagen in 2008, but COP 15 fell short of such goals. Commitments by developed countries under the Copenhagen Accord would achieve reductions of only 4-20% below 1990 levels by 2020, while the IPCC estimates that 25-40% reductions would be needed for a 50% chance of holding global temperatures below their target maximum increase of 2°C.[xvi] The 4-20% range is so large because many countries' commitments were conditional on the commitments of other countries; most notably, the passage of climate legislation in the US. Climate legislation failed to make its way through Congress in 2009 and is stalled for the foreseeable future. This policy failure will likely have a ripple effect through several of the countries party to the Copenhagen Accord. Participating developing countries were required to submit Mitigation Plans as part of the Accord, though those submitted by China and India (the main GHG emitters in the developing world) were based on reducing "emission intensity," or emissions per unit of GDP; this approach is expected to lead to less significant total emissions reductions.[xvii] Because of these limitations, crafting a strong international treaty has so far proven difficult.

While national climate legislation stalled in Congress in 2009, as mentioned above, the issue is likely to be raised again. The idea of the proposed climate legislation was to create a carbon market system, commonly known as Cap-and-Trade. The government would set a limit, or "cap" on carbon emissions, and distribute or auction off allowances to carbon emitters who could then buy and sell the allowances. Over time, the cap would become lower, hence reducing emissions on a national level. Others have proposed a direct tax on carbon as the most effective step toward a low-carbon future. Another proposed law is the Carbon 'Fee and Dividend' presented by Dr. James Hansen. A fee is charged at the point of origin or point of import on greenhouse gas emitting energy such as oil, gas, and coal. This fee gradually increases over time and is returned to the public[xviii]. In any case, energy prices are likely to rise over time, either because of climate legislation or as resources such as oil become scarcer as demand continues to rise.

It is in the interest of communities of all types to prepare for the future by reducing energy consumption and shifting toward cleaner technologies and social norms. Many local governments have joined together in recognition of the importance of climate action, forming the organization ICLEI (Local Governments for Sustainability), of which the Town of Carrboro is a member. Adopting more sustainable practices can help mitigate climate change, reducing the risks for severe environmental, economic, and social effects. These practices do not need to be considered from a position of compromise; strategies for lighter greenhouse gas footprints can also create jobs, save money, and improve public health.

1.5 The Role of GHG Emissions Inventories

In order to assess progress toward climate goals, it is important for communities to calculate GHG emissions inventories at regular intervals. These inventories provide information to communities about their overall emissions levels and also identify key emissions sources. A baseline inventory must first be compiled to establish a starting point from which the town can set goals for the future and measure its progress toward these goals over time.

2 METHODS

Carbon accounting is a data-driven process. Two major steps for quantifying GHG emissions are (1) data retrieval and (2) data analysis. While each step affects the other, a fundamental determinant of this project's treatment of data was the analytical software employed. In accordance with project guidelines, ICLEI's Clean Air & Climate Protection (CACP) 2009-edition software was used. The CACP software is designed for tracking, quantifying and reporting emissions from local government and community operations. The software complimented this project's goal of estimating Carrboro's public sector operations and community contributions as separate components. Some successes, limitations and assumptions of the software are elaborated upon in greater detail in the discussion section of this report.

2.1 Data Retrieval

To provide a comprehensive estimate for the town of Carrboro's GHG emissions from 2009, various data sets were gathered from sources internal and external to the town. The following tables report the types of data that were gathered as well as the sources from which they were acquired.

Table 2.1a - Carrboro Municipal Data Sets and Sources

Data Set	Source(s)
Electricity	Chapel Hill-Carrboro City Schools; Duke Energy; Town of Carrboro Planning Department
Heating Fuel	Town of Carrboro Planning Department; Chapel Hill-Carrboro City Schools
Water and Sewer Services	Town of Carrboro Planning Department; Chapel Hill-Carrboro City Schools; OWASA
Solid Waste Services	NCDWM; OCSW
Vehicle Fleet Fuel	Carrboro Public Works Department
Vehicle Fleet Vehicle-Miles Traveled (VMT)	Carrboro Public Works Department
Public Transit Fuel, VMT and GHG Emissions	Chapel Hill Transit

Table 2.1b - Carrboro Community Data Sets and Sources

Data Set	Source(s)
Electricity	Duke Energy; PEMC
Heating Fuel	PSNC
Solid Waste Services	NCDWM; OCSW
Community Transportation – Regional Transportation Models	CAMPO
Official Orange County and NC VMT Estimates	NCDOT

2.2 Data Analysis

Two sections comprise the following data analysis methods: the Public sector and the Community sector, as dictated by the CACP software entry requirements. Each sector is further subdivided into collection methods that include energy utilization (electricity consumption and heating fuel), water and sewage usage, and transportation. By providing these methods of analysis, the project team hopes to provide useful information for future GHG inventories.

2.2.1 Public Sector Data Analysis

Electricity Consumption

Data for electricity consumed by Carrboro's public sector in 2009 was entered into the CACP software in units of kilowatt-hours (kWh). These data include electricity consumed by town buildings, city schools and streetlights.

Average Grid Electricity Coefficients

A common method for calculating GHG emissions from electricity consumption is to multiply electricity consumption by an *emissions factor*, which expresses the emissions released from a unit of energy. Under optimal conditions, the emission factor precisely reflects the mix of fuel types used to produce the electricity consumed. The CACP software lacks ICLEI-supported emission factors for electricity consumption during 2009, so emissions factors from the U.S. Environmental Protection Agency (EPA) eGRID (version 2007) were supplied as suggested by the ICLEI-signed 2010 LGOP. According to the EPA:

> "The Emissions & Generation Resource Integrated Database (eGRID) is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States. These environmental characteristics include air emissions for nitrogen oxides, sulfur dioxide, carbon dioxide, methane, and nitrous oxide; emissions rates; net generation; resource mix; and many other attributes."

The emissions factor set used within the CACP software were eGRID technology averages. The most current EPA data from 2007, used in the 2010 Local Government Operations Protocol, was used to obtain default emissions factors for CO_2, N_2O, and CH_4 in lbs/MWh. Although the most recent information was published in 2007, this includes only inventories conducted through 2005. For inventories done for years after 2005, the protocol recommends using the most recent eGRID numbers that the EPA has calculated. Carrboro lies within the Virginia/Carolinas sub-region of the eGRID model, so emissions factors for this region were uploaded to the CACP software. This most recent eGRID emission factor table is shown in Appendix A.

Public Sector Data Collection

Public sector data included the electricity consumption for municipal buildings, streetlights/traffic signals and schools in Carrboro. Municipal buildings' data were obtained from the Carrboro Planning Department and the schools' data from the Chapel Hill-Carrboro City Schools. Data for streetlights and traffic signals were acquired from Duke Energy Corporation and PEMC. The municipal buildings' consumption was already totaled for 2009, so no further calculations were necessary. The schools provided monthly billing information for the 2008-2009 and 2009-2010 fiscal years, which yielded the 2009 calendar year data.

While accurate records for electricity consumed by Carrboro's town buildings and city schools were available, direct records for streetlight energy consumption were not. Duke Energy provided streetlight locations and electric power ratings in a Geographic Information Systems (GIS)-based format. To estimate electricity consumption by streetlights within Carrboro's city limits, the streetlight power ratings were multiplied by an estimate for the amount of time that they operated during 2009. According to Carrboro Planning Department staff, a reasonable way to estimate a streetlight's operating time for Carrboro's streetlights is to calculate the hours of darkness during the period of interest. An accurate means of calculating a location's annual hours of darkness is available online through the U.S. Naval Observatory's web site,[xix] which was used to generate a report for Carrboro's sunrise and sunset times for each day during 2009. This report was parsed to extract the hours of darkness for Carrboro during 2009 using a computer script authored in the Python programming language. This number of hours was multiplied by the streetlights' total electric power (in kilowatts) for 2009 to estimate streetlight electricity consumption (in kWh).

Heating Fuel

We obtained municipal data for natural gas and other heating fuels from the Carrboro Planning Department. These records were complete and up to date, which helped to streamline emissions analysis. It was determined that the town of Carrboro obtains its natural gas from PSNC. We were able to obtain GHG estimates from direct inputs to the CACP software.

Water and Sewer Services

When beginning our evaluation of the water and sewer services for the Town of Carrboro, we came upon a distinction between types of emissions. For example, the Jones Ferry facility, which is owned by OWASA and within the Carrboro town limits, emits directly into Carrboro. However, a notable amount of emissions are related to water and sewer operations that take place outside of our area of interest, yet still provide service to those consumers within the Town of Carrboro. This consumption of energy at these out-of-town locations produces emissions that must be attributed to the consumer within the town, because they are ultimately the cause of the pollution burden. Though these emissions are indirect, they are important to evaluate. The scopes through which the degrees of proximity of emissions are distinguished are defined later in this document. Since the more direct emissions coming from the Jones Ferry facility were addressed within the Duke Energy emissions calculations, these indirect municipal emissions became the center of our analysis for water and sewer services. The documents that provided data for this evaluation were summaries of energy use by OWASA and an account of water consumption by Carrboro municipal buildings.

To estimate the energy demanded by Carrboro for OWASA services, we used the water and wastewater flow volumes used to serve Carrboro during 2009 as a fraction of OWASA's 2009 Orange County totals. This fraction was then multiplied by the respective amounts of natural gas, electricity, gasoline, biodiesel (B20), and diesel used by OWASA to estimate the energy inputs necessary to serve Carrboro. Anderson Park used only sewage service, so we had to adjust our proportions based on sewage services only. Similarly, Carrboro Cemetery and Baldwin Park receive only water services, so we calculated their proportions based on water distribution services alone. The next step was to sum all of the public facilities' energy use by each energy type. This left us with total energy consumption by Carrboro municipal facilities, categorized by energy type (natural gas, electricity, gasoline, B100 biodiesel, and petrodiesel). The CACP software generated GHG emissions estimates from these energy inputs.

Solid Waste Services

With the assistance of OCSW, we obtained data reporting total tons of waste generated by municipal operations. Anaerobic decomposition of waste in the landfill generates significant amounts of methane, which has a GWP 21 times greater than that of CO_2.[xx] To accurately determine GHG emissions from Carrboro's municipal waste, it was necessary to determine municipal waste composition by material. The waste-sort data for Orange County waste, available to the public on the OCSW website, is listed below. The categories include paper products, food waste, plant debris, wood or textiles, and all other waste. The fraction of the total waste volume that each of these categories represents was entered into the CACP software along with the total tons of waste contributed by municipal operations, resulting in a GHG estimate.

Percentages for different waste composition categories required for the CACP software were matched with those most closely matching the OCSW breakdown:

1. Paper products = paper, 23.2%
2. Food waste = organics, 37.0%
3. Plant debris = yard waste, 1.8%
4. Wood and Textiles = Wood, 2.1%
5. All other waste = plastics, ferrous metal, non-ferrous metal, glass, inert, special waste, and brown goods; 35.9%

Vehicle Fleet Fuel Combustion

The Carrboro Public Works Department keeps accurate fuel consumption records using an electronic database to record the volume and type of all fuel dispensed to municipal vehicles. The town used two main fuel types in 2009, B20-biodiesel and gasoline. B20 is a mixture that contains 20% pure biodiesel (B100) and 80% petrodiesel, by volume. The CACP software can calculate GHG emissions from B100 and petrodiesel, but cannot directly calculate GHG emissions from B20. To find the respective amounts of B100 and petrodiesel within the town's B20 consumption, the volume of B20 was multiplied by 20% (to find the volume of B100) and by 80% (to find the volume of petrodiesel). The respective volumes of B100, petrodiesel and gasoline were entered into the CACP software, which used well-known emission factors to calculate the GHG emissions that resulted from the combustion of these fuels. The GHG emission factors for these fuels do not depend on the method of combustion, so differences in vehicle characteristics are negligible.

Public Transit Fuel Combustion

This project used Carrboro's 2009 fiscal contribution to the Chapel Hill Transit (CHT) bus system (which serves Chapel Hill, UNC and Carrboro) as a proxy for the share of CHT emissions that could be attributed to Carrboro residents. Other indicators were considered, such as ridership, the number of bus stops, and VMT. Fiscal measures were chosen to allow the other two CHT funding-entities to easily report their GHG emissions within the transit system; methodological differences (and incomplete or overlapping emissions inventories) may result when other indicators are used. Carrboro provides 15% of funding for Chapel Hill Transit and has done so since prior to 2009. Multiplying CHT's 2009 GHG emissions by 15% produced a defensible estimate for Carrboro's share of public transit emissions.

2.2.2 Community Data Analysis

Electricity Consumption

Residential & Commercial Sectors—Piedmont Electric Membership Corporation (PEMC)

Electricity consumption data already provided by PEMC to the Town of Carrboro prior to this project supported our analysis. The additional necessary calculations consisted of simply summing up the monthly consumption totals into one aggregate number for those addresses classified as residential and commercial. Since none of the data provided were classified as industrial Carrboro has a miniscule industrial sector, Duke Energy Corporation was taken as the sole provider of industrial electricity for Carrboro.

Residential Sector—Electric Utilities

Duke Energy provided county-wide electricity consumption data from 2009 but was unable to isolate Carrboro's portion of this total. The company was unable to release subscribers' addresses for privacy reasons, so it was not possible to compile the citywide data manually. However, the data were subdivided into residential, commercial, and industrial sectors, and separate data sets were provided for Orange County urban subscribers and subscribers who lived in Orange County but outside city limits. We determined a reasonable estimate of Carrboro's portion of electricity consumption for each sector as follows.

Demographic data about Carrboro and Orange County were available in the 2005-2009 American Factfinder census database. Population, number of housing units, number of rooms per household, and primary household heating fuel each were potential factors for comparison between Carrboro and Orange County. We chose to use the number of housing units as the preferred factor for comparison because this factor alone allowed for the use of the urban dataset only.

Because PEMC also supplies electricity to Carrboro residents, we subtracted the number of PEMC residential customers (acquired from PEMC 2009 consumption data) from the number of housing units in Carrboro (as shown in the census data) to determine the number of housing units served by Duke Energy. Duke Energy had provided the number of accounts for urban residents in Orange County for each month in 2009, and we approximated the year-long number of Orange County housing units served by averaging the number of accounts over the twelve-month period. We then calculated the ratio of number of housing units served by Duke Energy in Carrboro versus the number of housing units served by Duke Energy in all of urban Orange County. We attributed this portion (22%) of Duke Energy's Orange County urban electricity consumption to Carrboro for the purposes of this study.

The number of housing units should strongly affect electricity consumption. While electricity use increases for some activities (hot showers, for instance) depending on the number of occupants, each housing unit requires a base supply of energy for needs such as space heating and refrigeration. This portion of a housing unit's energy consumption is independent of the number of occupants; once a house is heated, adding more people will not increase the heating needs. Because of this base supply factor, we considered the number of housing units to be a strong indicator of electricity consumption.

As mentioned previously, we also considered total population, number of rooms per household, and primary household heating fuel as comparison factors. However, these would require comparison of Carrboro residents to *all* Orange County residents, regardless of whether they live in cities or not. It was possible to compare Carrboro residents to county-wide urban residents for the housing units estimate because the data Duke Energy provided detailed the number of accounts (and hence the number of households served) within cities. City dwellers likely have different electricity consumption levels on average than country dwellers due to greater prevalence of smaller multifamily units in cities and other factors.

While we ultimately chose to use the number of housing units as the comparison factor, we also calculated approximations for the other three factors. Using either total population or number of rooms per house as the primary factor yielded results that were within 2% of the housing units method. We rejected the heating fuel-adjusted method because of uncertainty about the percentage of household electricity consumption attributable to space heating in the region. We considered various estimates, but they were national numbers that did not reflect the climate of North Carolina. The proximity of the results from the three other methods suggests the figure calculated is a reasonable approximation of Duke Energy residential electricity consumption in Carrboro.

Commercial Sector—Electric Utilities

We also estimated the electricity consumption attributed to Duke Energy commercial customers. The Carrboro Planning Department provided the number of businesses in Carrboro, and we subtracted the number of PEMC commercial subscribers from that total. We attributed the remaining businesses' electricity consumption to Duke Energy.

The Duke Energy data showed the number of commercial accounts in cities in Orange County in 2009. We compared the number of Carrboro businesses subscribing to Duke Energy with the number of county-wide businesses doing so, and then used that fraction to isolate the emissions attributable to Carrboro's commercial sector.

This method assumes Carrboro businesses behave like "average" city businesses operating within Orange County. This is not necessarily the case. However, at 264 businesses, the numbers were too great to request utility bills directly from business managers. Furthermore, GIS land-use data were not sufficient because while Carrboro has these data, the Orange County data are available only from the middle 1990s.

Industrial Sector

Because there is only one operation in Carrboro town limits that is classified as industrial (Ready-Mix Concrete), we obtained electricity consumption data directly from the concrete plant operators via telephone and electronic communications. A production manager provided the average kWh used per day (209), which we converted to an annual total.

Heating Fuel

Methods equivalent to those employed for municipal heating fuel emissions were used to estimate community use of heating fuel; more specifically, natural gas. The community is also served by PSNC, and this data was retrieved from PSNC itself. Therms for residential, industrial, and commercial were included for the years 2008 and 2009. Therms were available in the form of addresses on a monthly basis for 2008 and 2009. For our purposes, these were put into aggregate form for the CACP software. A detailed report on the limitations of community propane use is available in the discussion section of this report.

Water and Sewer Services

Due to significant limitations in the CACP software, community-wide water and sewer GHG emissions were not estimated. A detailed discussion of these limitations is available in the discussion section of this report.

Solid Waste Services

Our methods in determining community emissions for solid waste services are equivalent to the process for public sector data analysis methods.

Community Vehicular Transportation

Comprehensive regional transportation models (RTMs) were employed to estimate GHG emissions released from vehicular transportation within Carrboro city limits during 2009. The Capital Area Metropolitan Planning Organization (CAMPO) currently produces an RTM every 5 years, with the most recent RTM made for 2005 as of this writing. CAMPO bases its models on the Triangle Regional Model, a unified four-step travel demand model that estimates vehicle miles traveled (VMT) based on trip generation, trip distribution, mode choice and route assignment. No RTM existed for 2009 during this project's execution and the 2010 CAMPO RTM was not yet released, so transportation for 2009 was estimated by interpolating between the 2005 CAMPO model and the 2015 CAMPO forecasting RTM (see Figure 2, below).

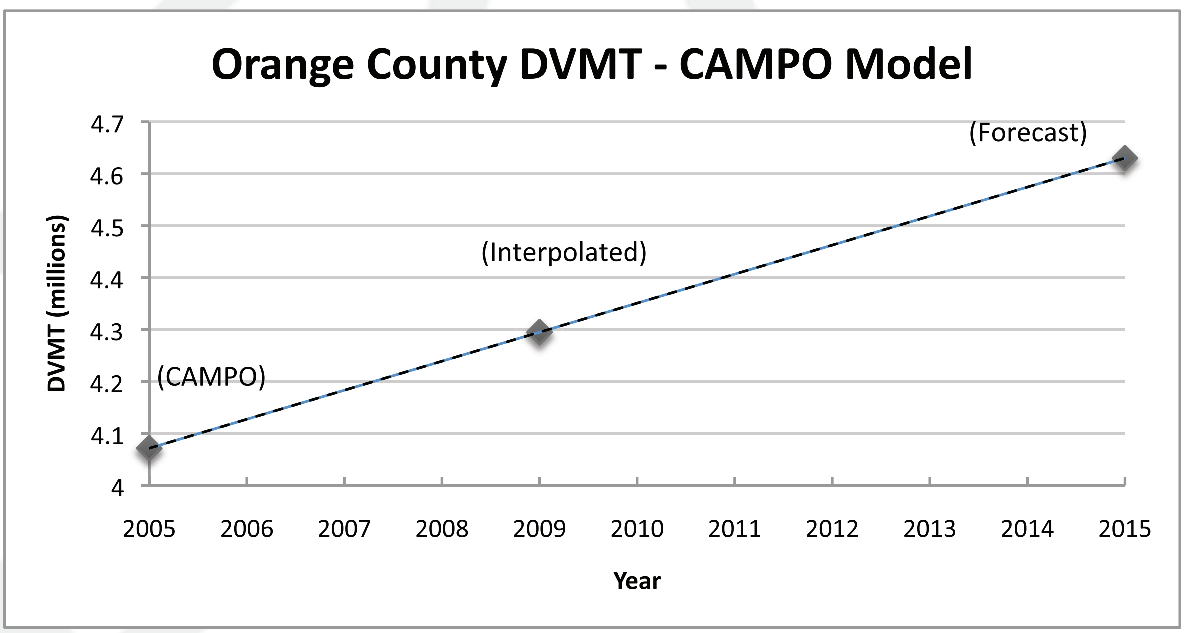


Figure 2

To interpolate 2009 annual VMT (AVMT), this project utilized a geographic information system (GIS) to capture RTM traffic “links” within two distinct areas of interest: (1) Orange County as a whole, and (2) Carrboro’s 2009 city limits. The use of Carrboro’s 2009 city limits caused some traffic links in the 2005 CAMPO RTM that were not located within Carrboro’s 2005 city limits to be captured within 2009 city limits, because Carrboro’s municipal boundary grew between 2005 and 2009. While the geographic extent of Carrboro’s 2005 city limits was available for this analysis, 2015 city limits are unknown and inestimable. Because 2005 and 2015 city limits were not both available, 2009 city limits (which have not changed at the time of this writing, according to Carrboro GIS data) were chosen to avoid skewing AVMT estimates toward a geographic extent that is unrepresentative of this project’s baseline year.

Interpolation involved summing DVMT for links within the respective areas of interest from the 2005 and 2015 CAMPO models using a GIS and calculating the average annual change in DVMT over that 10-year period. A sample formula is shown below:

Average Annual DVMT Change from 2005 to 2015 = Change in DVMT Change in Time = 2015 DVMT−(2005 DVMT)10 years

To interpolate 2009 DVMT, the average annual DVMT change was multiplied by four (the number of years between 2005 and 2009), the product of which was added to the 2005 DVMT value. A sample formula is shown below:

Interpolated 2009 DVMT=Average Annual DVMT Change from 2005 to 2015∗4 years+(2005 DVMT)

One interpolation was performed for each area of interest. One was performed for Orange County to calibrate the CAMPO RTM to NCDOT data, while another was performed for Carrboro to apply this calibration to 2009 estimates. CAMPO’s RTMs report traffic estimates in units of daily VMT (DVMT) for non-holiday weekdays. Traffic patterns differ significantly on weekends, during different seasons and on holidays. Therefore, CAMPO DVMT values cannot be converted to AVMT by multiplying by 365 days per year. To convert DVMT to AVMT while ensuring that Carrboro’s final transportation estimates agree with NCDOT estimates, 2009 DVMT for Orange County was interpolated using the CAMPO models and checked against NCDOT values. A CAMPO transportation engineer recommended finding the conversion factor needed to convert Orange County’s 2009 DVMT to NCDOT’s official 2009 AVMT estimate; we determined this factor and used it to convert Carrboro’s 2009 DVMT to AVMT. The AVMT value was entered into the CACP software, which uses assumptions about average fuel efficiency and fleet characteristics to generate GHG emissions estimates.

A drawback of estimating Carrboro’s automobile transportation within a geographic extent defined by its municipal limits is that this method only partially accounts for VMT associated with trips generated within city limits that end outside of city limits. These trips are likely frequent because limited employment is available within Carrboro; furthermore, various attractions such as commerce, health care and tourism encourage trips to destinations far from city limits. The transportation models available to us aggregate transportation demand in such a way that trips originating within Carrboro are indistinguishable from other types of trips, and only models covering very large extents with coarse scales tend to allow accurate disaggregation. The Triangle Regional Model is comprehensive and spans a massive number of entities and trip-generating attractions, meaning it is computationally overwhelming to accurately isolate trips made by Carrboro residents alone.

While the ability to more precisely track the Carrboro community's automobile transportation is desired to avoid underrepresenting the emission of GHGs by transportation relative to stationary sources (such as buildings), the transportation model employed in our analysis accounts for automobile transportation at a wide range of spatial scales and has been adjusted to match NCDOT estimates, which also account for trips that occur at fine and coarse spatial scales. This means our automobile transportation estimates account for nearly all traffic within city limits. In order to estimate automobile transportation by Carrboro residents alone, a survey of trip frequency, distance and fuel efficiencies for the Carrboro community may be necessary.

2.3 Data Entry

2.3.1 CACP Software

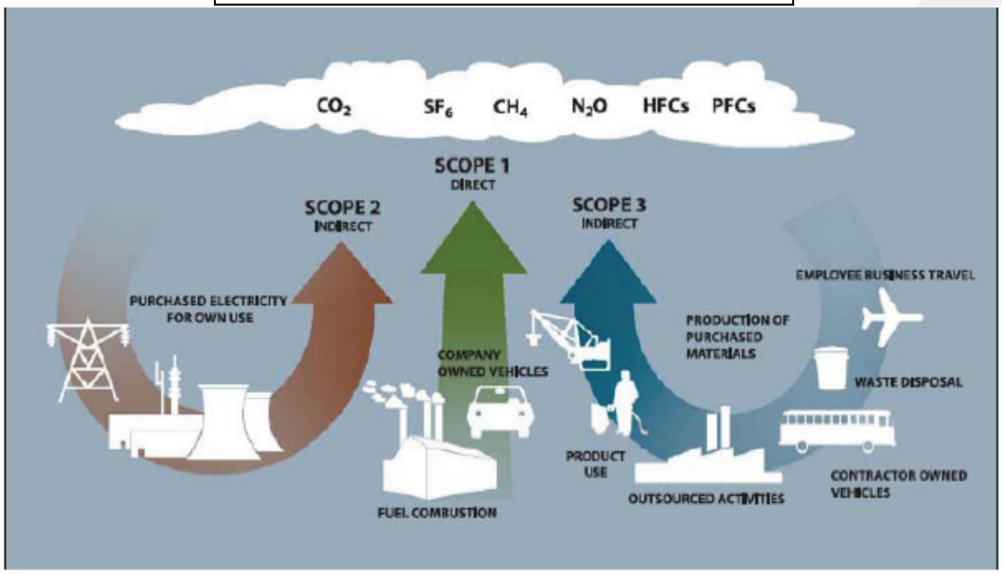
This inventory provides a public sector analysis as well as a community analysis to holistically represent the extent of Carrboro's GHG emissions. Residential, commercial, and community transport information is rare in a GHG emissions inventory, but is very relevant in discerning emissions trends for cities and for implementing a plan to reduce impacts on climate stability. Municipal operations, while important because they are under the control of town officials and staff, are only a small part of the activity contributing to Carrboro's carbon footprint. Estimating and reporting the impacts of the community at large is an ambitious but worthy additional challenge we took on to allow the town to understand and act on an assessment of the town's collective carbon impact.

2.3.2 Scope

Scopes I, II, and III are defined as the following:

1. Scope I: direct emissions from stationary and mobile fuel combustion
2. Scope II: indirect emissions from acquired energy such as electricity, heat, steam, or chilled water
3. Scope III: indirect emissions from product use, outsourced activities, production of purchased materials, contractor owned vehicles, waste disposal, employee business travel, and employee commuting

Overview of Scopes and Emission Sources



Source: WRI/WBCSD *GHG Protocol Corporate Standard*, Chapter 4 (2004).

Community Analysis

Using the CACP software Community analysis tool, values for the following were entered, dividing data into each scope in the most logical way:

Residential, Commercial, and Industrial

1. PSNC (Scope 1): direct fuel combustion by natural gas
2. Duke (Scope 2): purchased electricity
3. Piedmont Electric (Scope 2): purchased electricity

Transportation

1. Community Automobile Transport (Scope 1)

Waste

1. Orange County Solid Waste (Scope 3): classified as a Managed Landfill

Government Analysis

Using the CACP software Government Analysis tool, values for the following were entered, dividing data into each scope in the most logical way:

Buildings and Facilities

1. Century Center (Scope 1): direct fuel combustion by natural gas
2. Century Center (Scope 2): indirect purchased electricity from Duke
3. Fire Department (Scope 1)
4. Fire Department (Scope 2)
5. Other (Scope 2)
6. Public Works (Scope 1)
7. Public Works (Scope 2)
8. Town Hall (Scope 1)
9. Town Hall (Scope 2)
10. Total Schools (Scope 1)
11. Total Schools (Scope 2)

Streetlights and Traffic Signals

1. Streetlights (Scope 2): indirect emissions by purchased electricity from Duke and Piedmont

Water Delivery Facilities

1. OWASA (Scope 3): indirect emissions including electricity and natural gas consumption

Vehicle Fleet

1. Municipal Transportation (Scope 1): direct emissions from fuel combustion
2. OWASA (Scope 3): indirect emissions from facilities transportation and operations

Transit Fleet

1. Chapel Hill Transit

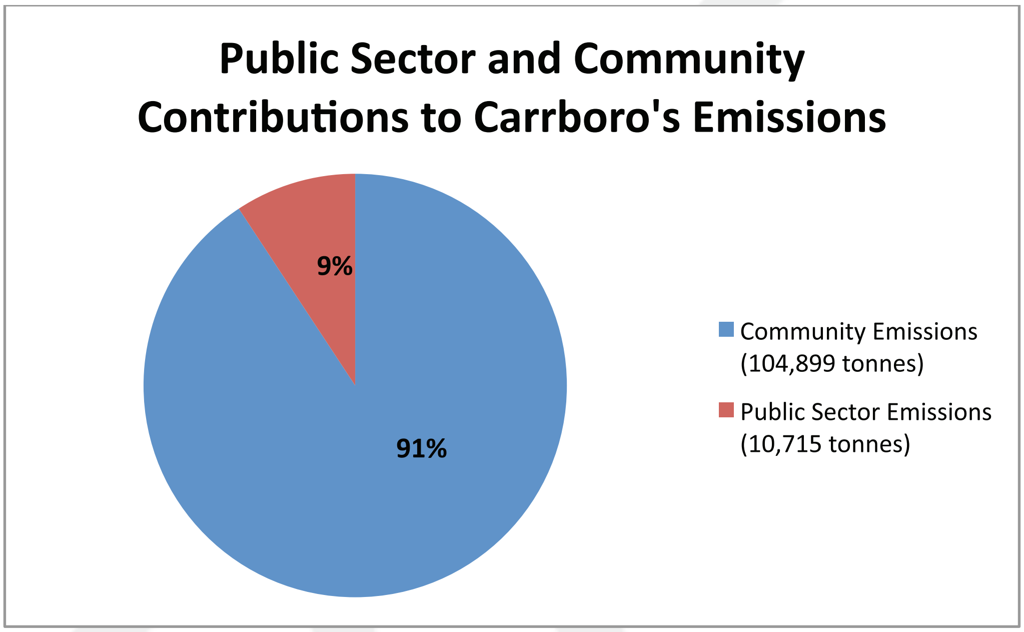
Separating Public Sector Totals from Community Totals

We decided for the purposes of this project to keep community analysis and public sector analysis separate, so that emissions totals fit together like two puzzle pieces. The public sector operations total, including schools in Carrboro, for electricity consumption and natural gas consumption were generated by the CACP Software for Government Analysis, but were also subtracted from the Community Analysis. OWASA water delivery estimations had to be divided between Water Delivery Facilities and Vehicle Fleet under government analysis due to limitations of the software. Limitations of these methods will be further explained in our discussion section.

3 Results

3.1 CACP Summary Reports

For the purposes of GHG reporting, emissions are discussed in terms of tonnes of CO_2 equivalent (CO_2e). Our estimate suggests that the community of Carrboro, excluding the public sector, emitted 104,899 tonnes of CO_2e in 2009. The public sector alone emitted 10,715 tonnes of CO_2e, and Carrboro as a whole, including both the public sector and the community, emitted a total of 115,614 tonnes of CO_2e.



The residential sector had the highest per capita emissions (3.0 tonnes of CO_2e per capita), followed by the transportation sector (1.8 tonnes of CO_2e per capita, for in town transportation only). These per capita results were generated using a 2009 population value for Carrboro of 19,891, as listed in the North Carolina Office of State Budget and Management's 2009 certified municipal population estimates.[xxi] Full per capita results are shown in the Indicators Report in Appendix A, and the Discussion section addresses the implications of these results.

Several other reports that show these results in greater depth were generated by the CACP software, and they highlight the following information:

- Public sector emissions by end use
- Public sector emissions by source (electricity, natural gas, diesel, etc.)
- Contributions of individual facilities to the total public sector emissions
- Community emissions by sector (residential, commercial, industrial, transportation, waste)
- Community emissions by source

- Contributions of individual utilities to the total community-wide emissions
- Per capita emissions for each sector

These reports are found in Appendix A.

3.2 Summary Graphs

Within the public sector analysis, buildings and facilities contributed the most emissions at 6,527 tonnes of CO_2e. Water delivery facilities made the next largest contribution, at 1,942 tonnes of CO_2e. The transit fleet, vehicle fleet, and streetlights made up smaller but significant portions of overall public sector emissions, and other emissions contributed comparatively little to the total. These results are shown in Figure 3 below.

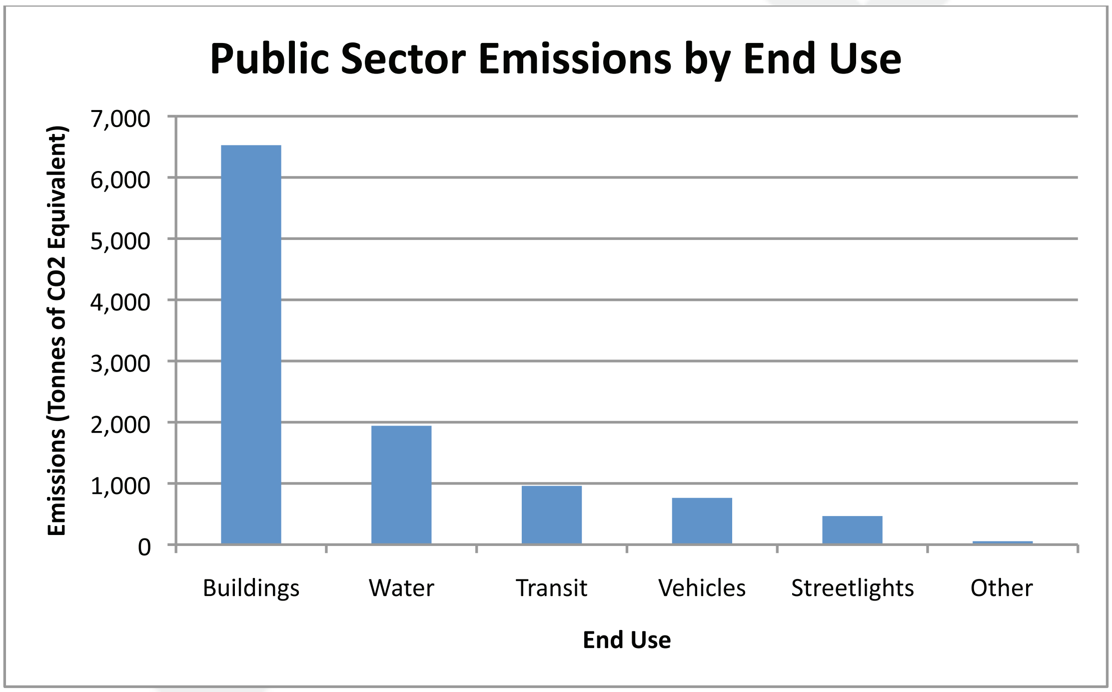


Figure 3. GHG emissions for the Town of Carrboro public sector operations in 2009, measured in tonnes of CO_2 equivalent. Emissions are divided by end use.

The relative contributions of different government facilities to overall emissions are also of interest. The following graph shows the electricity-related emissions by government building. It also shows the contribution of outdoor lighting. Analyzing these data is useful because electricity was the largest contributor to overall emissions. Outdoor lights were the largest source, followed by the Century Center.

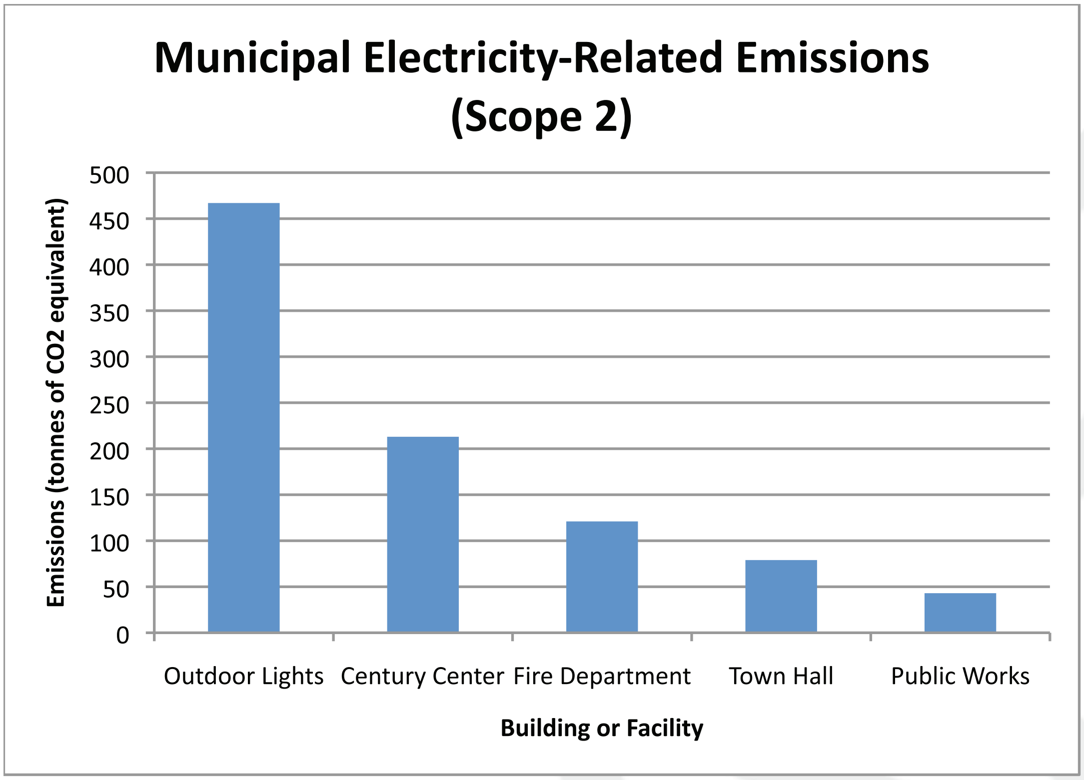


Figure 4: Emissions due to government electricity consumption (Scope 2) by facility.

Within the community-wide analysis, the residential sector contributed the largest amount of CO_2 equivalent at 53,121 tonnes. Transportation (for in-town transportation only) followed at 31,576 tonnes. This is shown below in Figure 5. The commercial sector also was significant, with waste and industry contributing very little by comparison.

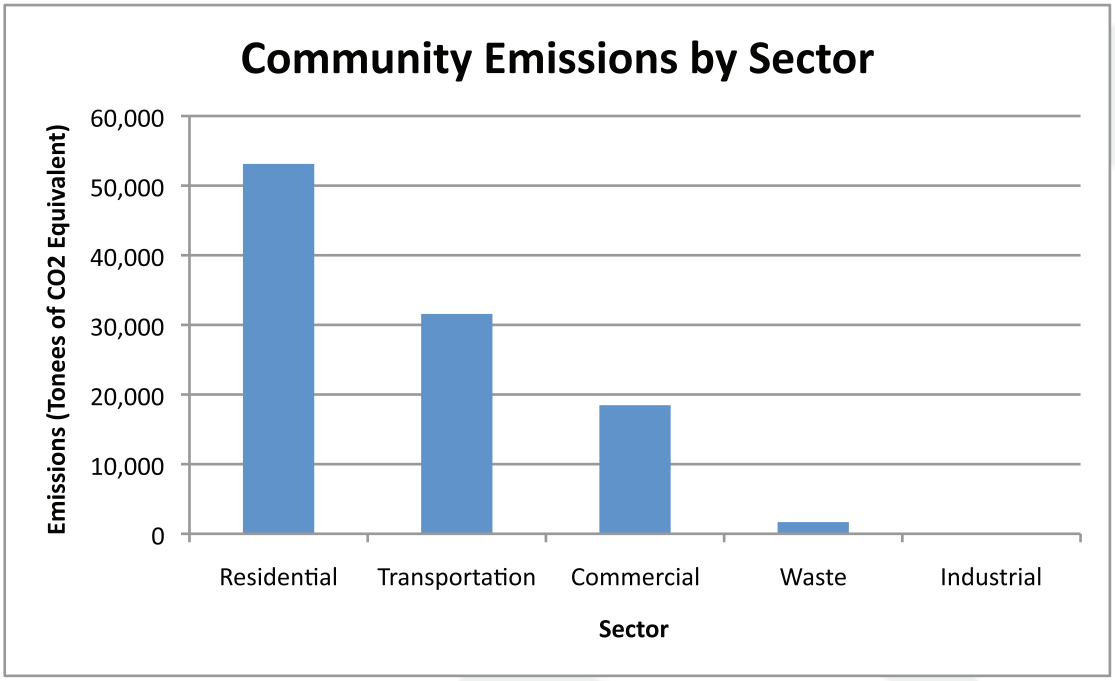


Figure 5: Community-wide GHG emissions for the Town of Carrboro in 2009, measured in tonnes of CO_2 equivalent. Emissions are divided by sector.

Because of the significant portion of emissions attributable to public sector, residential, and commercial buildings, the source of the majority of overall emissions was electricity. This is highlighted in the Report by Source in Appendix B, which shows electricity as the biggest emissions source, at 61,418 tonnes of CO_2e. Gasoline followed this at 26,438 tonnes.

For the public sector subset, natural gas followed electricity consumption as the next greatest source of emissions, with diesel and gasoline as smaller but significant contributors. These results are shown below in Figure 6.

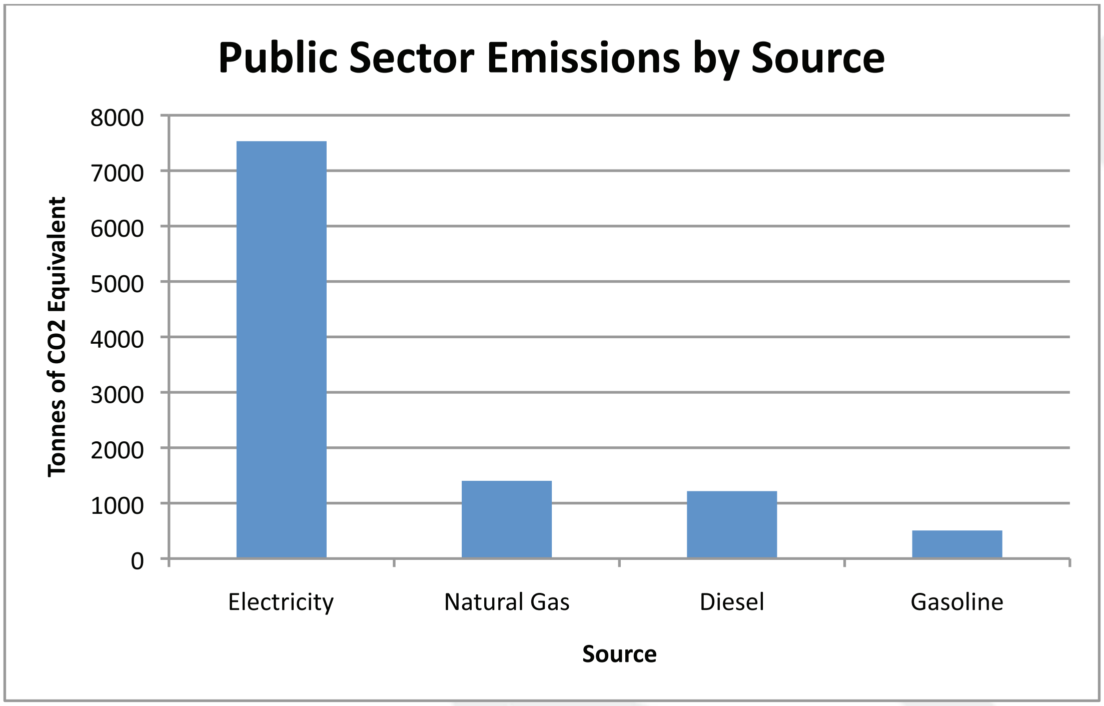


Figure 6: GHG emissions for the Town of Carrboro public sector operations in 2009, measured in tonnes of CO_2 equivalent. Emissions are divided by source.

For the community-wide analysis, electricity was again the clear primary source of emissions, followed by gasoline, natural gas, and diesel. Emissions from waste decomposition contributed comparatively very little to the total. These results are highlighted in the figure below.

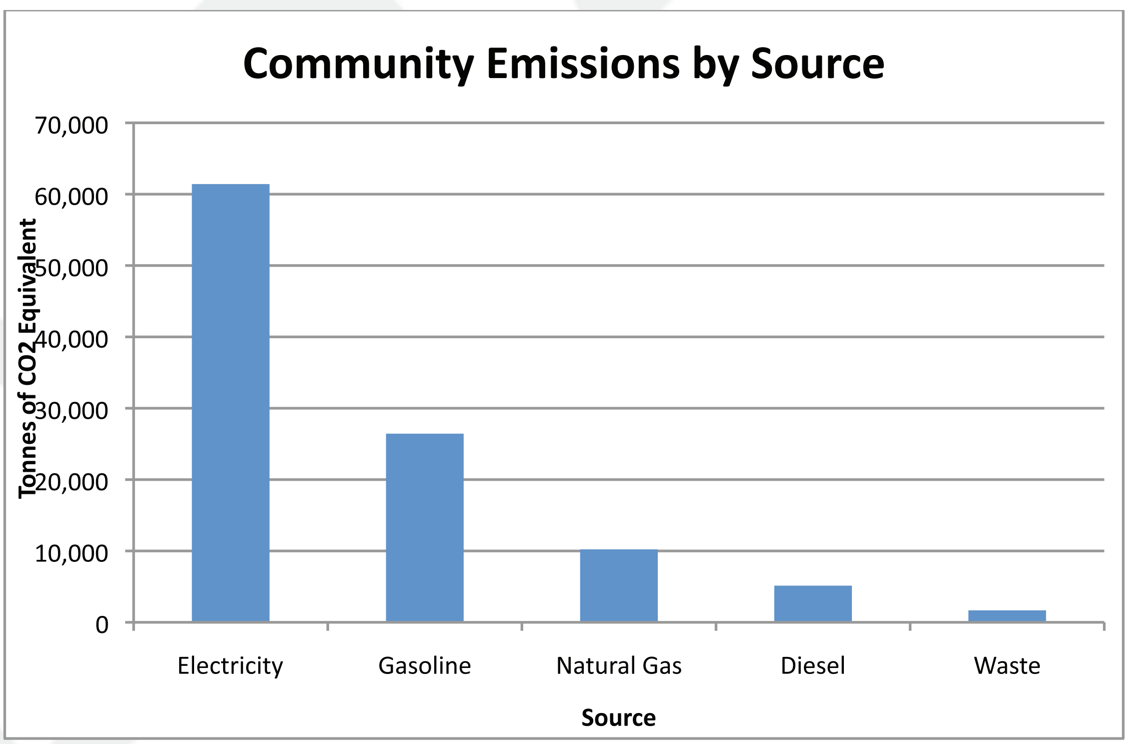


Figure 7: Community-wide GHG emissions for the Town of Carrboro in 2009, measured in tonnes of CO_2 equivalent. Emissions are divided by source.

These results highlight the areas with the greatest potential for overall emissions reduction. Programs that promote electricity conservation could affect more substantial reductions than conservation in other sectors, and accordingly such programs should be prioritized. Reducing car travel is the objective with the second-highest potential returns, followed by improving building insulation, which could reduce consumption of fuels used for space heating. An important caveat is that transportation is limited to in-town travel.

3.3 Emissions by Scope

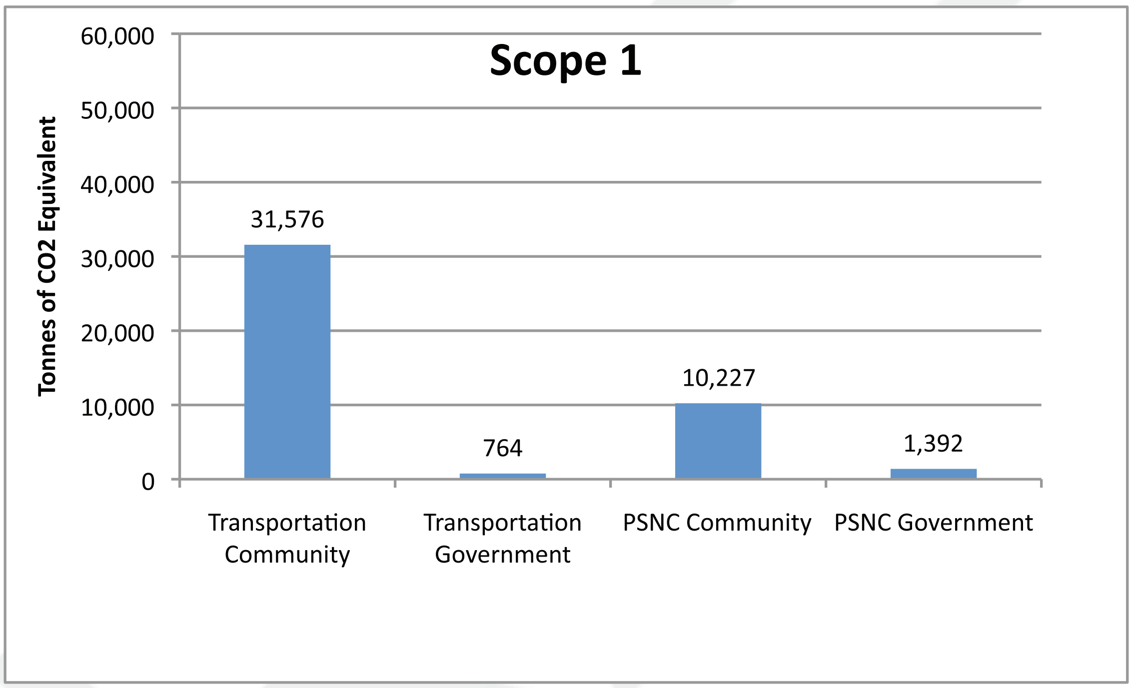


Figure 8: Scope 1 GHG emissions for the Town of Carrboro in 2009, measured in tonnes of CO_2 equivalent. Emissions are divided by source.

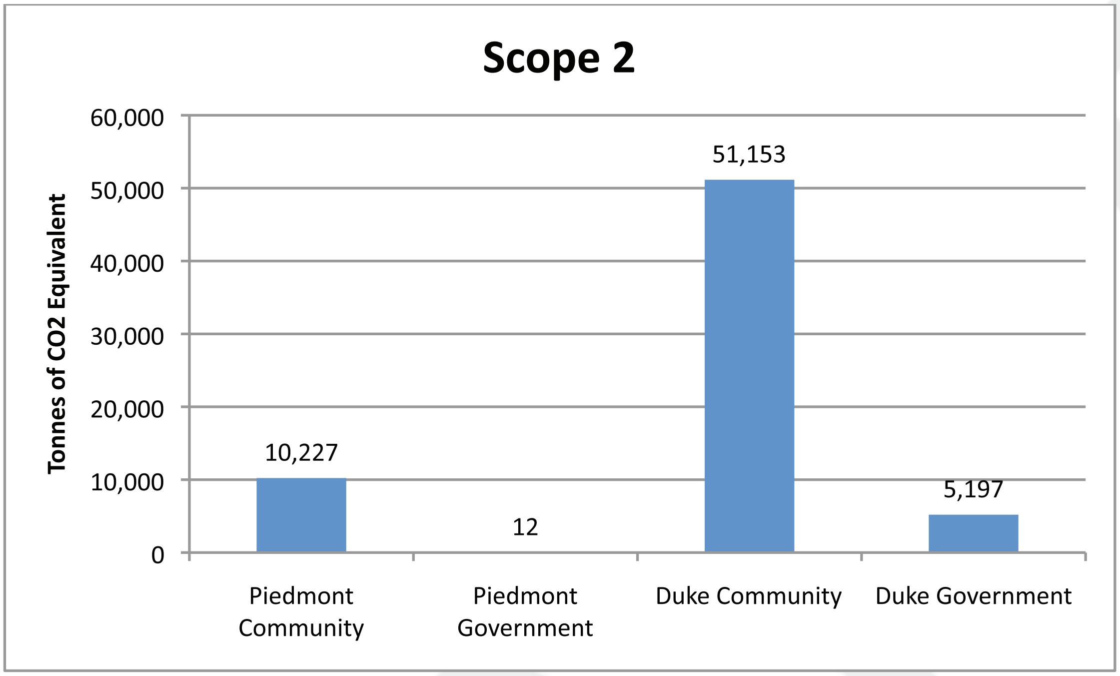


Figure 9: Scope 2 GHG emissions for the Town of Carrboro in 2009, measured in tonnes of CO_2 equivalent. Emissions are divided by source.

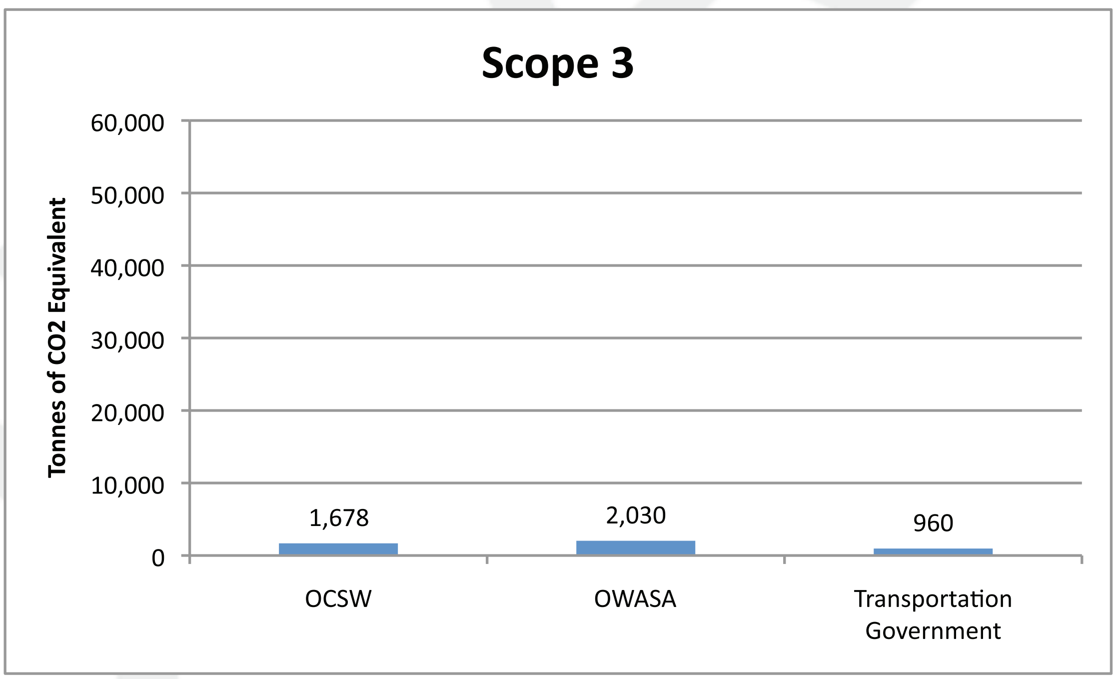


Figure 10: Scope 3 GHG emissions for the Town of Carrboro in 2009, measured in tonnes of CO_2 equivalent. Emissions are divided by source.

3.4 Emissions Breakdown Table - By Sector, Source, and Scope

FIGURE 11	Scope 1 GHGs (MTCDE)	Scope 2 GHGs (MTCDE)	Scope 3 GHGs (MTCDE)	Row Total (MTCDE)
Town of Carrboro Municipal Sources (excludes school and OWASA sources)				
Buildings and Facilities	100	484	-	584
Streetlights, Floodlights and Traffic Signals	-	467	-	467
Vehicle Fleet	676	-	-	676
OCSW	-	-	55	55
Public Transit* **(Chapel Hill Transit)**	-	-	960	960
Municipal Subtotals *(excluding Scope 3)*	***776***	***951***	***-***	***1,727***
Municipal Subtotals *(including Scope 3)*	***776***	***951***	***1015***	***2,742***
Town of Carrboro Public Sources (includes municipal, school, OCSW and OWASA sources)				
Schools (within municipal limits)	1,292	4,651	-	5,943
OWASA	-	-	2,030	2,030
Public Subtotals *(excluding Scope 3)*	***2,068***	***5,602***	***-***	***7,670***
Public Subtotals *(including Scope 3)*	***2,068***	***5,602***	***3,045***	***10,715***
Town of Carrboro Community Sources (excludes public sources)				
Residential	8,430	44,691	-	53,121
Commercial	1,782	16,687	-	18,469
Industrial	15	39	-	55 (due to rounding)
Transportation (within municipal limits)	31,576	-	-	31,576
OCSW	-	-	1,678	1,678
Community Subtotals *(excluding Scope 3)*	***41,803***	***61,417***	***-***	***103,220***
Community Subtotals *(including Scope 3)*	***41,803***	***61,417***	***1,678***	***104,899*** (due to rounding)
Town of Carrboro Sources (includes community and public sources)				
Town total *(excluding schools, excluding Scope 3)*	42,579	62,368	-	***104,946***
Town total *(including schools, excluding Scope 3)*	43,871	67,019	-	***110,889***
Town total *(including schools, including Scope 3)*	43,871	67,019	4,723	***115,614*** (due to rounding)

*While Chapel Hill Transit buses burn fuel, its GHG emissions are Scope 3 relative to Carrboro because the Town of Chapel Hill holds jurisdiction over routes, fuel purchases etc.

3.5 Carrboro Municipal Operations - 2005 and 2009 in Comparison

The following tables compare energy use, cost and GHG emissions for Carrboro's municipal buildings and facilities, public streetlights and vehicle fuel for calendar years 2005 and 2009. The municipal buildings and facilities included in these tables' "Buildings and Facilities" category include Carrboro Town Hall, Carrboro Public Works, the Carrboro Fire Department (Station No. 1), the Century Center and the Carrboro Farmer's Market. The term "energy refers to the total energy consumed, regardless of the energy source (such as electricity, gasoline, diesel, and so on). 2005 data were available from ICLEI - Local Governments for Sustainability's Greenhouse Gas Emissions Inventory and Forecast for Carrboro, Chapel Hill, Hillsborough and Orange County. That report groups Carrboro's park facilities within a category called "Buildings," which may be why it did not report building square footages; park facilities would significantly skew energy audits if counted as buildings in square footage values. Our report does not group park facilities in these tables' category, "Buildings and Facilities." To ensure comparability between the two inventories, energy consumption and cost data for park facilities were removed from the 2005 report's "Buildings" category.

Values marked with an asterisk * are flawed because of a significant data inaccuracy. The ICLEI emissions inventory miscalculated Carrboro's 2005 streetlight electricity consumption and GHG emissions by a factor between 15 and 20. This has been verified with multiple Carrboro staff. Our study's data for streetlights in 2009 were verified for accuracy by checking hard copy billing records against data from utilities.

A multitude of changes occurred between 2005 and 2009 that could have influenced changes in energy consumption and GHG emissions for Carrboro's municipal operations. Some growth indicators that may serve as proxies for increases in demand for municipal services are described below in Figure 12. Also of note is the vehicle fleet's change from petrodiesel to B20-biodiesel prior to 2009, and the rising cost of all automobile fossil fuels during this period. Municipal building square footage did not change. Natural gas prices fell significantly between 2005 and 2009, and it is important to know that—according to the emissions factors used by the CACP software—natural gas emits about 65% less CO_2e per unit of energy than the fuel mix used to produce electricity for the EPA eGRID subregion to which Carrboro belongs.

Growth Indicator	2005	2009	Change	% Change
Population	18493	19891	1398	7.56%
Municipal Land Area (sq. miles)	5.72	6.425	0.705	12.33%
Road Length (miles)	67.72	74.22	6.5	9.61%
Duke Streetlight Wattage (Watts)	136300	154900	18600	13.65%

Figure 12: Change in various indicators for the Town of Carrboro between 2005 and 2009

	2005 MTCDE (ICLEI)	2009 MTCDE (Our Study)	Change in MTCDE	% Change
Buildings and Facilities	541	555	14	2.6%
Streetlights	31*	467	436*	1406%*
Vehicle Fleet	636	676	40	6.3%
All Sources	1,208*	1,698	490*	40.6%*
All Sources (excluding streetlights)	1,177	1,231	54	4.6%

Figure 13: Change in MTCDE for Carrboro Municipal Operations between 2005 and 2009

	2005 Energy Costs (ICLEI)	**2009 Energy Costs** (Our Study)	**Change in Energy Costs**	**% Change**
Buildings and Facilities	$77,405	$82,279	$4,874	6.3%
Streetlights*	$11,317*	$132,106	$120,789*	1067%*
Vehicle Fleet	$124,317	$161,110	$36,793	29.6%
All Sources	$213,039*	$380,495	$167,456*	78.6%*
All Sources (excluding streetlights)	$201,722	$243,389	$41,667	20.7%

Figure 14: Change in energy costs for Carrboro Municipal Operations between 2005 and 2009

	2005 Energy Use (kWh) (ICLEI)	**2009 Energy Use** (kWh) (Our Study)	**Change in Energy Use** (kWh)	**% Change**
Buildings and Facilities	1,374,055	1,434,458	60,403	4.4%
Streetlights	46,896*	878,285	831,389*	1773%*
Vehicle Fleet	2,566,091	2,920,777	354,686	13.8%
All Sources	3,987,042*	5,233,520	1,246,478*	31.3%*
All Sources (excluding streetlights)	3,940,146	4,355,235	415,089	10.5%

Figure 15: Change in energy use for Carrboro Municipal Operations between 2005 and 2009

4 Discussion

In this section, we offer insights into some of the successes, limitations and assumptions of the project that were necessary to complete our analysis. Data collection can oftentimes become constrained due to a lack of access to information, or inefficient methodologies that are beyond the capacity of the researchers to control. Here, we explain how this process might be streamlined, and explain some of the assumptions that we have made in order to provide transparency and justification that will be useful to future projects of this nature.

4.1 CACP Software and Data Entry

Our original goals included comparing the 2009 baseline inventory estimations to 2005 conditions as a "back-casting" exercise to explain recent trends in emissions production. This could also be used to provide forecasts for future years if a 2005 estimate could be entered into the CACP software in a fashion similar to our 2009 data entry. Indeed, we hope that in the near future it will be possible to compare current and past years using similar reports generated by the software. This task has also been impeded by the inability for Duke (the main electricity provider) to provide electricity data for the year 2005; which created a formidable challenge for such an endeavor. However, forecasting future inventories could be performed using appropriate growth indicators and factors specific to Carrboro, provided the necessary data are systematically collected henceforth. At the moment, our studies have not been carried out to provide the data necessary to perform such a forecast.

The CACP software presented major limitations in the process of separating public sector and community values. Categories of data entry within the program did not always correspond directly when moving between "government" and "community" analysis, making it difficult to simply subtract public sector values from community totals for each utility. Also, Scopes are not defined within the software, and any representation of scopes was performed solely by our team. They were represented within the charts generated by CACP software by labeling each tab in the title as either scope 1, 2, or 3. Within public sector buildings and facilities, each building has a "Scope 1" tab as well as a "Scope 2" tab.

Scope 3

Secondly, there was no option under Community Analysis to provide for the Scope 3 emissions that result from the purchase of water, in this case, OWASA. Therefore, no approximation of GHG emissions could be made for the community, but it was made for public sector operations. Furthermore, only part of OWASA's energy consumption, electricity and natural gas, could be entered under the Water Delivery Facilities tab, so vehicle consumption had to be included in the Vehicle Fleet tab along with municipal transportation. Therefore municipal transportation is skewed because it reflects Scope 1 direct emissions from the municipal fleet, as well as Scope 3 indirect emissions from OWASA's operations. For these reasons, descriptive labels including scopes are provided in the emissions report to adequately illustrate the breakdown. As previously discussed in the results section, transportation is the second largest contributor to the community analysis total. Since Waste Water Facilities contributed such a large amount to the public sector analysis total, we can speculate that this could have also contributed a large amount to the community analysis

Finally, accounting for solid waste facilities fell under Scope 3, but contributes significantly to Carrboro's emissions. It was simple to input tonnage of solid waste under community analysis through the Waste tab, but there was not a similar option under government analysis, which only provided for Solid Waste Facilities energy consumption. Since OCSW data was provided only as tons of generated solid waste, instead of energy consumption by the facility, this could be used only for community. To incorporate the GHG generation into municipal values, we first entered it into the community analysis to see the appropriate equivalents of methane production from the tonnage of municipal waste. It was possible to input the equivalent methane generation under the Other Process Fugitive tab in Government Analysis to generate an equivalent value for total public sector operations.

4.2 Heating Fuel

A small portion of homes in Carrboro are heated with propane. However, propane retailers within Carrboro were unable to provide records about the volume of propane sold in 2009. Even if sales receipts could be obtained, we would not know if the propane bought within Carrboro town limits was actually burned within town limits; furthermore, Carrboro propane users could have bought their fuel in nearby towns.

Census data showed the percentage of Carrboro homes (1.3%) heated with bottled, tank, or liquefied petroleum (LP) gas, but because propane was not listed alone, it was not possible to isolate the portion of homes heated with it. The EIA keeps records of state-level LP gas consumption, but not propane specifically. Because of these data gaps, it was impractical to calculate a reasonable approximation.

4.3 Solid Waste

Regarding solid waste, the public sector contributed to a very small portion of the community whole. However, according to our results, in 2005 the average Carrboro citizen generated 3.2 pounds of waste per day. In 2009, only 2.3 pounds of waste per person per day were generated. According to the EPA, the national average amount of waste generated per person per day is 4.3 pounds.[xxii] Thus, Carrboro puts considerably less waste into the landfill on average than the rest of the country. Furthermore, discussions with city professionals have indicated that this it is due to financial constraints during times of an economic recession.

The major limitation to our determination of solid waste emissions is that OCSW only keeps data for the entire county, not data separated out for Carrboro. We made assumptions on Carrboro's portion of the county's whole.

OCSW was not able to provide us with data by calendar year, rather by fiscal year. We were able to obtain information based only on fiscal year 2004-2005 and 2008-2009. As indicated by OCSW staff, we maintain that there is no significant change between fiscal year and calendar year.

The waste composition data obtained from OCSW was taken from a solid waste composition study done in 2010 of the entire town of Carrboro. There are no waste sort data specifically for public sector operations.

Keeping these constraints in mind, we believe that this was the most feasible and accurate method of measurement with the data available to us.

4.4 Transportation

Automobile transportation within municipal limits represents a significant portion (nearly 30%) of Carrboro's community GHG emissions. This is likely a result of the separation of home, work and play for Carrboro citizens and Piedmont residents in general. While Carrboro offers a thriving downtown, very few Carrboro households lie within one-quarter of a mile of Carr Mill Mall and Weaver Street Market, which is the distance cited by the U.S. Green Building Council as a reasonable walking distance around which to design walkable neighborhoods.[xxiii] Combined with the region's highly decentralized employment and relatively low urban density, this greatly increases automobile dependence for Carrboro citizens and encourages transportation-related GHG emissions. In a post-recession economy where unstable energy prices are unlikely to abate, this issue threatens to burden Carrboro with economic, environmental and social pressures, even if automobile dependence in the community remains constant or decreases in the future. Consider that gasoline alone for Carrboro's municipal vehicle fleet cost $94,215.34 in calendar year 2009 at an average price of $2.04 per gallon; if the average price increases to $4.00 per gallon, Carrboro will pay nearly twice as much (nearly $188,000) to move the same vehicles the same distance. Even if environmental and social pressures fail to make the case for a more sustainable transportation model, the economic burden of maintaining or increasing automobile-dependent activity in Carrboro is likely to do so.

A drawback of estimating Carrboro's automobile transportation within a geographic extent defined by its municipal limits is that this method only partially accounts for VMT associated with trips generated within city limits that end outside of city limits. These trips are likely frequent because limited employment is available within Carrboro; furthermore, various attractions such as commerce, health care and tourism encourage trips to destinations far from city limits. The transportation models available to us aggregate transportation demand in such a way that trips originating within Carrboro are indistinguishable from other types of trips, and only models covering very large extents with coarse scales tend to allow accurate disaggregation. The Triangle Regional Model is comprehensive and spans a massive number of entities and trip-generating attractions, meaning it is computationally overwhelming to accurately isolate trips made by Carrboro residents alone.

While the ability to more precisely track the Carrboro community's automobile transportation is desired to avoid underrepresenting the emission of GHGs by transportation relative to stationary sources (such as buildings), the transportation model employed in our analysis accounts for automobile transportation at a wide range of spatial scales and has been adjusted to match NCDOT estimates, which also account for trips that occur at fine and coarse spatial scales. This means our automobile transportation estimates account for nearly all traffic within city limits. In order to more accurately estimate automobile transportation by Carrboro residents, a survey of trip frequency, distance and fuel efficiencies for the Carrboro community may be necessary.

4.5 OWASA Data Considerations

Public sector water emissions accounted for 19% of the 2009 emissions for the town of Carrboro. We were unable to acquire data for community consumption that was split up into the five necessary CACP categories (residential, commercial, industrial, transportation, and other). However, as previously mentioned, the operations of the Jones Ferry facility, which is in a direct scope and creates emissions attributable to the Town of Carrboro community, were accounted for within Duke Energy emissions records.

We were able to procure accurate data for the annual water usage of each public building within Carrboro. However, when entering data into the CACP software, the user must record the total amount of energy in all facilities for each source—natural gas, electricity, gasoline, biodiesel, and diesel. Since we didn't have data that divided the energy used for services into the aforementioned five sections, we were forced to make calculations. We took the total water consumption for each public facility and applied it to the annual energy distribution data provided by OWASA in order to divide the public water and sewer emissions into the five energy categories. The assumption that we created in this instance was that the distribution of energy usages by water and sewer services for each facility were exactly the same or even comparable to energy use by OWASA as a whole.

In summary, we were unable to procure community water and sewage consumption data, simply because the records of these activities were not preserved. For the public sector, we were able to acquire water and sewer usage data; however, it was not in a format that was conducive to the CACP software. This misalignment led to us having to make manipulations and subsequent assumptions. In future, the Town of Carrboro and OWASA should collaborate to ensure that both public and community water and sewage consumption data are archived. In addition, the next generation of software may be more malleable than the CACP software that we used; a less rigid form of data entry would allow for fewer assumptions.

4.6 Backcasting and 350.org.

In order to supply Carrboro with a backcasting analysis, we would require uniform data access across all sectors, from utility companies to propane outlets, dated as far back as 2005. This goal was simply beyond our reach. Specifically, 2005 data were not available for the public sector operations as Duke Energy Corporation, the supplier, was unable to provide billing data (which they had only for 2007 and not for 2005). This is significant, considering electricity would have been the biggest source with which to compare previous levels; however, this was simply not possible to calculate. Additionally, with regards to 2005 comparisons, if we were to attempt to compare our results with another report there could be significant methodological differences. The only way to do this as accurately as possible would be to attain the raw data and use our own methods.

Carrboro requested that we conduct a final analysis that links its carbon footprint to the 350 ppm climate change awareness movement, *350.org*. This organization is committed to creating a social awareness campaign to communicate the impacts of climate change as global carbon dioxide emissions have reached a level of 350ppm—a level that is associated with "the safer upper limit of carbon dioxide in the atmosphere."

After further discussion and research, the capstone team concluded that the use of *350.org* may not be the best motivational tool for conveying the seriousness of climate change and Carrboro's contribution to it. It has been widely debated in the environmental communication field as to whether the use of a number, such as 350 ppm, as a social mobilization device is effective in inspiring citizens to take action. Additionally, 350 ppm is a global goal that cannot be narrowly applied to a smaller scale, such as a town or even a country. The atmosphere of the earth is a fluid entity, one that is affected by all countries, nations and cities; however, to attempt to characterize the impact of one section of the atmosphere would prove inadequate and possibly misleading. In fact, a more useful tool might be found in the IPCC report (Intergovernmental Panel on Climate Change), which indicates that a more effective GHG reduction methodology is to set targets and develop a plan that outlines step by step goals. For instance, UNC-Chapel Hill has committed to setting carbon footprint reduction goals, by signing the American University President's Climate Commitment; they have pledged to achieve climate neutrality by 2050.

Thus, we hope our final recommendations provide Carrboro with a clear view of where they are headed in terms of GHG emissions, and suggest alternative pathways to reduce those emissions.

In light of these limitations, we have not provided a backcasting report with a final analysis comparison to the 350.org movement; however, we have provided relatable comparisons that we believe will be more effective as a motivational tool for Carrboro and its citizens.

4.7 Comparisons and Illustrations

While accurate data analysis and quantitative charts are extremely useful tools for city planners and government officials, it is equally important to communicate this information in a relatable fashion to Carrboro's citizens, to instill or deepen a sense of personal responsibility and local action. In this section, we offer a comparative analysis of carbon emissions in direct relation to the research findings we have generated. It is also important to note that these comparisons are slightly skewed because we are missing Piedmont data from a few municipal facilities, namely, pond fountains and public park bathrooms. And as we have previously stated, solid waste numbers were generated for the community, but not the public sector; conversely, OWASA numbers were generated only for the public sector and not community. These incongruities may slightly skew our analysis; however, the baseline carbon emissions data that we have generated provide a strong platform with which to begin conveying comparative analyses.

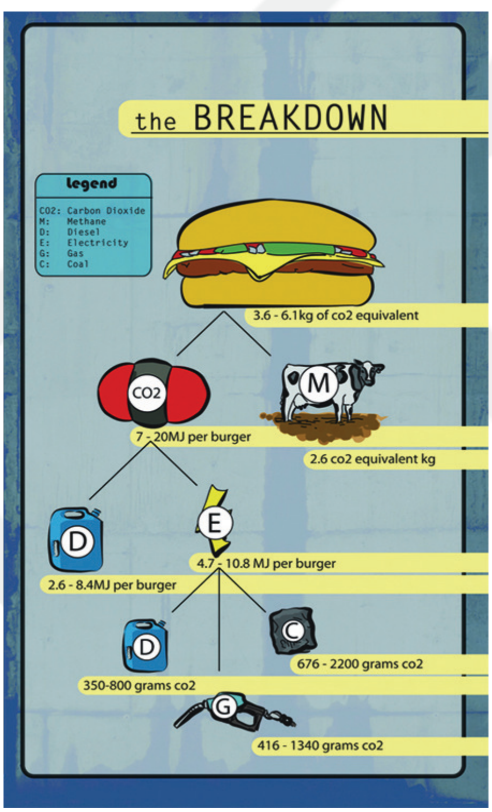
Comparison to US and the World

The United Nations Statistics Division frequently releases statistical analyses comparing its 200-plus member nations. Pertinent to this study is an analysis the United Nations Statistics Division releases every few years ranking the nations based on their CO_2 emissions per capita (tonnes CO_2 per capita). The United Nations' main goal in conducting this report is to foster environmental responsibility to ensure global sustainability by providing relative performance measures for its member nations. This analysis therefore aims to encourage the integration of sustainable development principles into national policies and thought processes, to help reverse the loss of critical environmental resources and environmental degradation.[xxiv]

Using this report to weigh the Town of Carrboro against the rest of the nation allows one to see exactly where the town stands in comparison to the national average. This comparison also conveys how the average Carrboro citizen fares compared to the average American citizen. Even more interesting is the comparison that can be made between the Town of Carrboro and other countries. If we assume that everyone in the United States emitted GHG's like Carrboro citizens, we can see exactly how the citizens of Carrboro are performing compared to the rest of the world.

The 2009 CO_2e emissions per capita for the Town of Carrboro equal 5.8 tonnes. This is one-third of the average emissions per capita for the United States as a whole (18.9 tonnes). If everyone in the United States emitted CO_2 like Carrboro citizens, at 5.8 tonnes per capita, we would rank 68th on the list of countries' CO_2 emissions. This would put us before The Republic of China, which currently ranks 68th at 5.7 tonnes per capita, and after the Venezuela, which holds the 67th position at 5.9 tonnes per capita[xxv]. Other countries ranking higher than Carrboro include Australia, Canada, Singapore, Germany, Spain, Italy, and France.

The Town of Carrboro's absence of industry and industrial processes within the town limits undermines its remarkably low emissions per capita. Industry and industrial processes comprise 13.8 percent of the world's GHG emissions. This is part of the reason why Carrboro's emissions per capita are so low. The lack of agriculture in our inventory also contributes to the why the Town of Carrboro's GHG emissions per capita are lower than expected. Agriculture and industry combined encompass 27.3 percent of the world's GHG emissions[xxvi], and 23.1 percent of the United States GHG emissions[xxvii]. The absence of these activities within the town limits means that our comparison to the rest of the nation and the world is somewhat skewed, and that the average Carrboro citizen does not necessarily emit 1/3 the amount of GHG's of the average American citizen. (Recalculating the town's GHG emissions per capita using the world or U.S. average for agriculture and industry would not be a fair assumption, and therefore it has not been done.) However it does show that in many respects the Town of Carrboro is ahead of other localities in its global sustainability. Keeping the considerations of the lack of industry and agriculture in mind is however very important to understanding Carrboro citizens and its municipal operations still have room to improve their daily operations in terms of GHG emissions.



http://sustainontario.com/wp-content/uploads/2011/01/Hughes-Steven-Food-.jpg

Cheeseburgers and Hummers

Let us look at an unconventional comparison that is quintessentially American—the cheeseburger. A study conducted by the Stockholm University's Environmental Strategies Research Group and the Department of Systems Ecology in collaboration with the Department of Civil and Environmental Engineering at the Swiss Federal Institute of Technology calculated the environmental impact of cheeseburgers.[xxviii] The carbon footprint of a simple cheeseburger includes several points of production, such as growing and milling the wheat for the bread, feeding and slaughtering cattle, and processing an amalgam of preservatives, sugars and spices to supply condiments. Their study concluded that the average cheeseburger with embodies a carbon footprint of between 3.6 and 6.1 kg of CO_2

equivalent. According to further analysis by futurist author and renowned lecturer Jamais Cascio, after including the average number of hamburgers that Americans consume individually—roughly 3 per week (or 150 per year)—the nation's cheeseburger-related carbon emissions amount to 195,750,000 tonnes of CO_2 equivalent per year. Additionally, considering on average that an E3 Hummer emits 11.1 tonnes of carbon dioxide equivalent over the course of one year, (which is significant because the EPA estimates that passenger vehicles emit 5.5 MTCDE per year, and are roughly driven 10,500-12,000 miles/year), the MTCDE of our American burger diet equates to roughly 19.6 million Hummer E3 SUVs driven for a year.[xxix] In terms of the Town of Carrboro's CO_2 equivalent output of 115,614 tonnes for 2009, (and averaging the MTCDE of a hamburger to 4.85 kg of CO_2e) this would translate to 23,837,938 hamburgers or roughly 10,415 new Hummer E3 SUVs on the town fleet roster for one year. According to 2000 census data, this would mean that every Carrboro citizen from age 15-54 would be able to drive a Hummer for one year.

Carrboro vs. Chapel Hill: A Municipal per capita Comparison

Due to the close proximity of Chapel Hill to Carrboro, and the available information provided by the 2005 ICLEI Greenhouse Gas Emissions Inventory and Forecast for Chapel Hill, Carrboro, Hillsborough, and Orange County, a comparison of municipal emissions is feasible.[xxx] In 2005, the population for Chapel Hill was 49,543 and as reported by ICLEI, the town's municipal carbon emissions (counting only buildings, streetlights, the vehicle fleet and solid waste, to maintain parity with our 2009 data) were 8,173 MTCDE.[xxxi] With the population and emissions data for Carrboro and the population and emissions data for Chapel Hill we arrive at the following:

Figure 16 – Carrboro Municipal 2009 Emissions vs. Chapel Hill Municipal 2005 Emissions (only buildings, streetlights, vehicle fleet and solid waste)

	Population (Year)	MTCDE	CO_2e/person (kg)
Chapel Hill	49,543 (2005)	8,173	165
Carrboro	19,891 (2009)	1,782	90

While Carrboro was about two and a half times smaller in 2009 in population than Chapel Hill, it currently produces almost half as much kg of CO_2 equivalent as Chapel Hill's 2005 levels. This comparison can be helpful, particularly when demonstrating the value of determining baseline GHG emission reports; providing a clearer picture of current carbon emission scenarios across town and city boundaries.

CO_2 and Breathing

An interesting comparison that reveals the high degree of GHG activity by humans is to consider current levels of GHG emissions relative to the amount of CO_2 that people create through respiration alone. This comparison can serve as a method of demonstrating how many individuals' worth of CO_2-equivalent emissions current Carrboro citizens emit relative to natural breathing alone. The comparison below assumes that average values for respiratory rates and gas exchange within the human body are reasonable estimates for a wide variety of age groups.

According to the Carbon Dioxide Information Analysis Center at the Oak Ridge National Laboratory,[xxxii] people add approximately 0.037 grams of CO_2 to the atmosphere with each breath. A University of Florida medical guide to vital signs[xxxiii] indicates that normal resting respiratory rates for adults are between 14 and 20 breaths per minute; the central value of 17 is taken as an average. By estimating the number of breaths taken by Carrboro citizens in 2009 and multiplying it by the amount of previously sequestered carbon that each breath adds to the atmosphere in the form of CO_2, a rough estimate for the amount of CO_2 added to the atmosphere by Carrboro citizens through breathing alone is found:

Carrboro 2009 Respired CO2 in tonnes

=0.037 g CO2breath∗1 tonne106g∗17 breathspersonminute∗525,600 minutesyear∗19,891 people in Carrboro in 2009

=*6576* tonnes (CO2)

According to this report, Carrboro emitted 115,614 tonnes of CO_2 equivalent in 2009 (including community and public sector sources). This is almost 18 times more CO_2-equivalent than the 2009 population may have released into the atmosphere through breathing alone; in other words, each Carrboro citizen emitted as much CO_2-equivalent as 18 individuals who do nothing but breathe all year. While this comparison is simplistic, it serves to illustrate how the comforts of modern life rapidly multiply our environmental footprint to the point that people today impact the planet several times greater than people of the past. When this trend is compounded by booming global population growth—especially growth in industry-dependent developing countries—a striking picture begins to emerge of how the planet as a whole can be impacted by the thousands of small communities like Carrboro, thus justifying the town's efforts to curb GHG emissions.

Forest Cover

Carrboro's 2009 emissions can also be conceptualized by considering the amount of forest cover that would be required to offset them, because trees and other plants sequester CO_2 through photosynthesis as they grow. According to an analysis by the EPA, forests sequester approximately 3666 kilograms (8066 pounds) of CO_2 per acre per year.[xxxiv] To offset its 2009

CO_2 emissions completely, Carrboro would therefore need to plant a forest of approximately 49 square miles, or slightly less than eight times larger in area than the town itself.[xxxv]

We hope this section has given the reader a sense of the many ways in which carbon equivalent comparisons can be utilized to provide a deeper understanding of how every dimension of humanity has an environmental impact. The following recommendations are an attempt to create a shift in Carrboro's carbon footprint, now that these impacts have been communicated.

5 Recommendations and Conclusion

5.1 Recommendations

The team has identified several actions that could help the Town of Carrboro achieve substantial GHG emissions reductions. The recommendations fall into three categories: stationary structures, programs and policies, and the GHG inventory process.

5.1.1 Stationary Structures

Stationary structures—such as buildings and facilities—comprised the largest source of GHG emissions in Carrboro in 2009 for both the public sector and the community as a whole. Electricity and heating fuel used by public structures released 61 percent of all public CO_2 equivalent, while electricity and heating fuel used by non-public structures released 68 percent of all non-public CO_2 equivalent Accordingly, significant GHG reductions are possible by improving the efficiency of structures in the Carrboro community.

Electricity consumption was the most significant cause of GHG emissions in Carrboro, so it presents many opportunities for energy savings. All traditional incandescent light bulbs should be replaced with Compact fluorescent light bulbs (CFLs) or Light-Emitting Diodes (LED)s. According to an emissions calculation system compiled by the US EPA and the DOE, using one Energy Star qualified CFL instead of an incandescent bulb saves approximately 314 kg (691 pounds) of CO_2 over the lifetime of the bulb; CFLs require 75% less energy and also last ten times longer.[xxxvi] CFLs are also a more responsible option financially than incandescent bulbs because of significantly lower energy costs. The EPA estimates that these savings can amount to up to $62 over the bulb's lifetime.[xxxvii] Simple conversion of remaining incandescent bulbs to CFLs could therefore achieve significant results. This should be required in all municipal buildings and facilities and strongly encouraged in the residential and commercial sectors.

Choosing Energy Star-certified appliances is another way to reduce electricity-related GHG emissions. Government facilities should be required to purchase these energy-efficient appliances when replacing outdated equipment, and they should be promoted to the residential and commercial sectors of Carrboro. In 2010, the state of North Carolina incentivized residents to upgrade to Energy Star appliances by offering rebates.[xxxviii] If financially feasible, the Town could offer a similar rebate program to encourage an affordable transition to these more-responsible technology options.

Emissions from natural gas and electric space heating can be reduced by carefully controlling thermostats and improving insulation. Programmable thermostats can reduce wasted energy from heating and cooling buildings when the buildings are unoccupied. Residents and building managers can pre-set these thermostats to adjust the temperature to different levels depending on the time of day. Room temperature should also be adjusted seasonally; UNC Energy Management policy, for example, recommends setting summer indoor temperatures to 76-78°F and winter indoor temperatures to 69-71°F.[xxxix] For example, many homes typically have their daytime temperature higher than their nighttime temperature to account for the outdoor temperature changes associated with heat from the sun. Another common practice is to have the home temperature naturally acclimate to the outdoor temperature when no one is in the home, for example when homeowners are at work during the day.

Improved insulation can encourage significant energy savings by retaining more of the heated or cooled air within a building. Window quality can also influence heat retention in homes, though windows can be expensive and difficult to replace in older structures. Installing energy-efficient windows in existing homes can provide upwards of 21 percent savings on heating and up to 12 percent savings on cooling.[xl] Due to their high cost, however, widespread window upgrades are likely unrealistic in the current economic climate. Energy audits should be encouraged to identify the most cost-effective weatherization strategies for individual buildings.

Water use is a secondary but important area of interest; it represents 12.9 percent of 2009 public sector emissions. The Town of Carrboro and OWASA already require progressive water conservation standards that aim to reduce water waste. The standards stipulate the following: spray irrigation is restricted to a maximum of three days weekly, and alternatives such as drip irrigation are encouraged; xeriscaping (landscaping with native, less water-intensive plants) is encouraged; household water efficiency devices such as low-flow showerheads and ultra-low flow toilets are encouraged; restaurants must supply customers with water only on request; and hotels must wash linens only once per stay unless a guest requests otherwise.[xli] Other water conservation policies, tips, and suggestions, such as the use of rainwater catchment structures and conservative water use behavior, are readily available on OWASA's website.[xlii] Access to this information is important, because significant energy savings are possible in the water consumption arena.

For example, the installation of low-flow showerheads and sink aerators can reduce home water consumption by as much as 50 percent and reduce the energy cost of heating water by as much as 50 percent. According to Figure 6 from Appendix A, water treatment and delivery services emitted 1,942 tonnes of CO_2 equivalent in 2009, which accounts for approximately 18.1 percent of the total public sector emissions. Assuming a portion of Carrboro's buildings have already been retrofitted with energy-efficient water technologies such as low-flow showerheads and toilets, it is reasonable to estimate that the town could save approximately 580 tonnes of CO_2 equivalent (assuming a 30 percent reduction) through complete transition to water saving methods. The American Water Works Association estimates that indoor water consumption can be reduced by 35% to a total of 45.2 gallons per person per day by installing readily available water-efficient fixtures and appliances and by minimizing leaks.[xlvi] Another consumption-reduction option is low flow toilets. Some of the first low-flow toilets did not work effectively, but the technology has progressed enough that they now work well and are affordable.

Water heating uses about 17% of the energy in US homes and ranks as the second largest household energy expense after space conditioning.[xlvi] The encouragement of solar domestic hot water systems could provide up to 70% of the annual water heating load. These systems are relatively inexpensive for the cost savings homeowners could enjoy over its lifetime, and are very reliable with proper upkeep and maintenance.

One problem with the current model is that many of the measures outlined in OWASA's water conservation document are voluntary. Restrictions on certain uses of water must be followed, especially during times of water scarcity, but for the most part the document relies on an informed and engaged citizenry to take initiative and get involved. We recommend that the Town mandate water-efficient technologies in all municipal buildings. This would reduce the public sector GHG footprint and serve as a model for the community. We are concerned that the public may not be fully aware of OWASA's efforts and the water conservation information resources it has made available; if this is the case, substantial energy savings may not be realized in the residential and commercial sectors. Greater emphasis on education and public outreach could be useful for achieving community-wide adoption of more sustainable water behaviors and technologies. Recommendations for increased outreach will be discussed in the Policies and Programs section of this report.

5.1.2 Programs and Policies

There are several policy approaches Carrboro can take to reach its GHG emissions goals. One option is to modify its solid waste collection programs. Currently Carrboro uses blue bins to collect its recycling and collects it weekly. If Carrboro switched to large recycling containers like the ones Charlotte currently uses,[xliii] it could reduce recycling pickup to every other week and reduce fuel consumption by recycling trucks while also saving money on operating costs. Carrboro could also adopt a Pay-As-You-Throw (PAYT) system for garbage collection. In such systems, customers are billed for garbage collection depending on how much trash they generate.[xliv] This encourages recycling and composting and reduces the amount of material sent to landfills. PAYT programs are in practice in communities across the United States. In 2006, for example, nearly 50% of the communities in California used some form of PAYT.[xlv]

Another key emissions reduction opportunity is changing to LED streetlights. This would be far more energy-efficient, though the Town does not have direct control over streetlights so it would need to coordinate this with Duke Energy (Duke Energy leases the streetlights to Carrboro). The Town could also mandate the use of environmental-performance contracting, in which municipal contractors could earn bonuses by meeting certain benchmarks or criteria, such as LEED certification on buildings.

One way for Carrboro to make GHG measures on the residential scale is the encouragement of smart growth. While this does not affect GHG emissions currently, it is a good investment to make to reduce the rate of GHG emission growth in the future. By protecting natural systems and encouraging dense development, green areas can be preserved as parks or for trails, where some carbon can be offset through plants. The encouragement of public transportation will also discourage the use of automobiles, reducing emissions from total population automobile usage. There are a large number of ways in which smart growth can be encouraged. According to the Department of Energy's Green Building Guidelines, some effective methods include tax incentive programs, housing density bonuses, flexibility in zoning code requirements, increased lot coverage, increased building height, and floor area bonus[xlvi]. Also, encouragement of brownfield and greyfield site usage by developers can provide future GHG reductions.

Carrboro could also provide stricter guidelines on construction waste management. The easiest way to do this is to mandate reduced packaging, and the recycling of waste lumber. The town could also mandate waste audits for each construction project, which can be used to determine where waste can be eliminated on future jobs. The encouragement of increased recycling of construction materials can also reduce the need for new products, thus reducing GHG emissions. It is generally regarded that a builder's jobsite waste is 60% to 80% recyclable.[xlvi]

There are examples across the country that can offer Carrboro different ideas on what cities and towns can effectively implement. For example, in Los Angeles, the Southern California Gas Company started an energy resource center to show off recycling and upcoming energy-efficient technologies. Its primary use was to present the latest in energy-efficient appliances, designs, and materials.[xlvii] Another example is in Portland, Oregon, where the planning department for the city started the BEST business center, which encourages sustainability and efficiency among small businesses.[xlviii] The organization gives out highly coveted awards for businesses that excel in this area, and they give free evaluations for companies that wish to improve their energy efficiency. If Carrboro put in a program similar to this it would spur economic development while simultaneously decreasing GHG emissions.

We recommend that Carrboro set up an energy resource center of its own, perhaps in the form of an Energy Efficiency Exhibit at the Century Center. Displays could explain climate change and the role of energy efficiency in reducing GHG emissions, as well as provide pragmatic steps for citizens to take to reduce their impact. Energy efficiency saves money on utility bills in addition to reducing harmful emissions, so citizens would also find the displays useful from a practical financial perspective. The town could start an energy resource center by introducing energy efficiency technologies in existing municipal structures in order to avoid the cost and GHG emissions associated with new construction. Another option may be to convert a qualifying historic building to an energy resource center while taking advantage of federal and state historic building rehabilitation tax credits, which range from twenty to forty percent. Several districts within Carrboro are listed in the National Register of Historic Places, so buildings within these areas may be excellent candidates for a reduced-cost energy resource center.[xlix]

It would be most effective for the Energy Efficiency Exhibit to include tangible items and visuals for citizens to see and experience. For example, sample CFL and LED light bulbs should be on display, as well as information detailing quantified energy and monetary savings over the bulbs' lifetimes and where they can be purchased for home use. Another item that could be included in the exhibit is a smart power strip. Smart power strips shut off electricity to subordinate devices (such as printers and monitors) when the primary device (such as a computer) is turned off, reducing wasted electricity that these electronics continue to consume when they are turned off but still plugged in. The Kill-a-Watt is another device that would fit well with the exhibit. This device measures the amount of power that various electronics consume. Exhibit visitors could plug in their everyday electronics to the Kill-a-Watt to find out how much energy they could save by leaving electronics unplugged when not in use. The exhibit could display many of the water conservation tips and guidelines available on OWASA's website, and low-flow showerheads and other water efficiency technologies could be represented. The Energy Efficiency Exhibit could be a potential destination for school field trips as well, and it could help raise community awareness about this critical issue.

Carrboro could encourage energy conservation in its municipal buildings by holding a competition between occupants of different town buildings for the greatest percent reduction in energy intensity. These data could be tracked by inputting billing records into a database such as the EPA's online Portfolio Manager; Porfolio Manager analyzes billing records in terms of various indicators, including GHG emissions and energy intensity.

Carrboro already has some relevant programs, and it should continue to build upon the programs already in place. It is partnered with Chapel Hill in the Worthwhile Investments Save Energy (WISE) program, which has been very successful. Carrboro has focused to date on a commercial energy efficiency revolving loan fund, and is looking to expand the program into the residential sector.[1] This program shows significant promise toward the goal of reducing GHG emissions, and we strongly recommend Carrboro's continued involvement in its development.

5.1.3 The GHG Inventory Process

From our experiences in gathering data for this inventory, it is apparent that records deemed necessary for Carrboro backcasting and forecasting are kept at varying degrees of availability and accuracy. For example, Duke Energy kept data only for the past 2 years, making it was impossible to perform a backcasting analysis in relation to this utility. We recommend that Carrboro staff update records every January to include compiled data for all energy and emissions activities, including data from Duke Energy Corporation, PSNC, Piedmont Electric, OWASA, Chapel Hill Transit, Carrboro Public Works Department (vehicle fleet), and OCSW. Other organizations where it is important to obtain information from are outlined in the methods portion of this report. Maintaining these records will allow the town to perform backcasting and forecasting inventories in the future. As it stands, it was extremely difficult for our team to perform any sort of backcasting or forecasting due to data discrepancies and our hesitation to make extreme assumptions. Complete and accessible records will allow Carrboro to reach its emission goals and may also serve as a risk management asset should greenhouse gas emissions become priced in the future.

One way to aid the process of further data gathering and analysis would be to enlist a Developing Energy Leaders Through Action (DELTA) student energy intern from UNC-Chapel Hill's Institute for the Environment. This would allow the process for data collection to be updated—and possibly streamlined—without additional cost to the town, as these interns are funded through ARRA federal funding. Furthermore, an intern could help implement other programs we have recommended, such as the Energy Efficiency Exhibit and the energy conservation competition. Partnering with the Institute for the Environment would provide a mutual benefit for the town and the student intern: an opportunity for the student to develop energy-related skills in a professional setting and an opportunity for the town to continue to develop GHG reduction strategies.

6 Conclusion

In this report we have analyzed Carrboro's baseline GHG emissions for 2009 and where possible beyond. This data analysis will hopefully provide the city with a firm foundation on which to base further research and strategies upon. It is our hope that the methods outlined in this document provide a clear understanding of the process of emissions auditing as one that hinges on access to relevant data, and a willingness to explore new and innovative ways of calculating and communicating such findings. The realm of GHG emissions auditing is evolving quickly as cities and towns are becoming more engaged and concerned about their contribution to a changing climate and its shifting resources.

Carrboro has taken a bold step towards recognizing the difference that informed and engaged citizenry can make in terms of "Thinking Globally, Acting Locally," to quote an environmental adage. While it is beyond the scope of this project to indicate the future of Carrboro's GHG emissions as a whole, we are confident that these materials present the town with a clearer understanding of their current baseline of emissions in this climate change era.

Appendix A- CACP Charts

Table 1

eGRID subregion acronym	eGRID subregion name	Annual output emission rates		
		Carbon dioxide (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (lb/GWh)
AKGD	ASCC Alaska Grid	1,232.36	25.60	6.51
AKMS	ASCC Miscellaneous	498.86	20.75	4.08
AZNM	WECC Southwest	1,311.05	17.45	17.94
CAMX	WECC California	724.12	30.24	8.08
ERCT	ERCOT All	1,324.35	18.65	15.11
FRCC	FRCC All	1,318.57	45.92	16.94
HIMS	HICC Miscellaneous	1,514.92	314.68	46.88
HIOA	HICC Oahu	1,811.98	109.47	23.62
MROE	MRO East	1,834.72	27.59	30.36
MROW	MRO West	1,821.84	28.00	30.71
NEWE	NPCC New England	927.68	86.49	17.01
NWPP	WECC Northwest	902.24	19.13	14.90
NYCW	NPCC NYC/Westchester	815.45	36.02	5.46
NYLI	NPCC Long Island	1,536.80	115.41	18.09
NYUP	NPCC Upstate NY	720.80	24.82	11.19
RFCE	RFC East	1,139.07	30.27	18.71
RFCM	RFC Michigan	1,563.28	33.93	27.17
RFCW	RFC West	1,537.82	18.23	25.71
RMPA	WECC Rockies	1,883.08	22.88	28.75
SPNO	SPP North	1,960.94	23.82	32.09
SPSO	SPP South	1,658.14	24.98	22.61
SRMV	SERC Mississippi Valley	1,019.74	24.31	11.71
SRMW	SERC Midwest	1,830.51	21.15	30.50
SRSO	SERC South	1,489.54	26.27	25.47
SRTV	SERC Tennessee Valley	1,510.44	20.05	25.64
SRVC	SERC Virginia/Carolina	1,134.88	23.77	19.79

Source: EPA Clean Energy eGRIDweb GHG Emissions Factors

Figure 1

Carrboro

Community Greenhouse Gas Emissions in 2009
Summary Report

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Equiv CO_2 (%)	Energy (ekWh)
Residential	52,840	791	1,723	53,121	50.6	132,742,895
Commercial	18,368	293	515	18,469	17.6	42,044,924
Industrial	55	1	1	55	0.1	160,874
Transportation	31,008	1,730	1,472	31,576	30.1	127,522,340
Waste	0	0	79,886	1,678	1.6	
Total	102,271	2,814	83,597	104,899	100.0	302,471,033

Figure 2

Carrboro

Community Greenhouse Gas Emissions in 2009
Report by Source

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Equiv CO_2 (%)	Energy (ekWh)
Diesel	5,133	15	16	5,138	4.9	20,559,834
Electricity	61,061	1,065	1,279	61,418	58.6	118,617,773
Food Waste	0	0	36,921	775	0.7	
Gasoline	25,875	1,715	1,456	26,438	25.2	106,962,506
Natural Gas	10,201	19	960	10,227	9.7	56,330,920
Paper Products	0	0	40,899	859	0.8	
Plant Debris	0	0	1,018	21	0.0	
Wood or Textiles	0	0	1,048	22	0.0	
Total	102,271	2,814	83,597	104,899	100.0	302,471,033

Figure 3

Community Greenhouse Gas Emissions in 2009
Detailed Report

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Equiv CO_2 (%)	Energy (ekWh)
Residential						
Carrboro, North Carolina						
Duke (Scope 2)						
Electricity	37,076	647	777	37,292	35.6	72,023,412
Subtotal Duke (Scope 2)	37,076	647	777	37,292	35.6	72,023,412
Piedmont (Scope 2)						
Electricity	7,356	128	154	7,399	7.1	14,290,059
Subtotal Piedmont (Scope 2)	7,356	128	154	7,399	7.1	14,290,059
PSNC (Scope 1)						
Natural Gas	8,408	16	792	8,430	8.0	46,429,425
Subtotal PSNC (Scope 1)	8,408	16	792	8,430	8.0	46,429,425
Subtotal Residential	52,840	791	1,723	53,121	50.6	132,742,895
Commercial						
Carrboro, North Carolina						
Duke (Scope 2)						
Electricity	13,742	240	288	13,822	13.2	26,694,790
Subtotal Duke (Scope 2)	13,742	240	288	13,822	13.2	26,694,790
Piedmont (Scope 2)						
Electricity	2,848	50	60	2,865	2.7	5,533,228
Subtotal Piedmont (Scope 2)	2,848	50	60	2,865	2.7	5,533,228
PSNC (Scope 1)						
Natural Gas	1,778	3	168	1,782	1.7	9,816,906
Subtotal PSNC (Scope 1)	1,778	3	168	1,782	1.7	9,816,906
Subtotal Commercial	18,368	293	515	18,469	17.6	42,044,924

Figure 4

Carrboro

Community Greenhouse Gas Emissions in 2009

Indicators Report

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Energy (ekWh)
Residential					
Sector Average					
Per capita	2.7	0.0	0.1	2.7	6,673.5
Commercial					
Sector Average					
Per capita	0.9	0.0	0.0	0.9	2,113.8
Industrial					
Sector Average					
Per capita	0.0	0.0	0.0	0.0	8.1
Transportation					
Sector Average					
Per capita	1.6	0.1	0.1	1.6	6,411.1
Waste					
Sector Average					
Per capita	0.0	0.0	4.0	0.1	

Figure 5

Carrboro

Community Greenhouse Gas Emissions in 2009
Report by Subsector

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	(%)	Energy (ekWh)
Residential						
Carrboro, North Carolina						
Duke (Scope 2)	37,076	647	777	37,292	35.6	72,023,412
Piedmont (Scope 2)	7,356	128	154	7,399	7.1	14,290,059
PSNC (Scope 1)	8,408	16	792	8,430	8.0	46,429,425
Subtotal Residential	52,840	791	1,723	53,121	50.6	132,742,895
Commercial						
Carrboro, North Carolina						
Duke (Scope 2)	13,742	240	288	13,822	13.2	26,694,790
Piedmont (Scope 2)	2,848	50	60	2,865	2.7	5,533,228
PSNC (Scope 1)	1,778	3	168	1,782	1.7	9,816,906
Subtotal Commercial	18,368	293	515	18,469	17.6	42,044,924
Industrial						
Carrboro, North Carolina						
Duke (Scope 2)	39	1	1	39	0.0	76,285
PSNC (Scope 1)	15	0	0	15	0.0	84,589
Subtotal Industrial	55	1	1	55	0.1	160,874
Transportation						
Carrboro, North Carolina						
Community Transport (Scope 1	31,008	1,730	1,472	31,576	30.1	127,522,340
Subtotal Transportation	31,008	1,730	1,472	31,576	30.1	127,522,340
Waste						
Carrboro, North Carolina						
OCSW (Scope 3)	0	0	79,886	1,678	1.6	
Subtotal Waste	0	0	79,886	1,678	1.6	
Total	102,271	2,814	83,597	104,899	100.0	302,471,033

Figure 6

Carrboro

Government Greenhouse Gas Emissions in 2009
Summary Report

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Equiv CO_2 (%)	Energy (ekWh)	Cost ($)
Buildings and Facilities	6,494	92	238	6,527	60.9	17,586,908	0
Streetlights & Traffic Signals	464	8	10	467	4.4	901,246	0
Water Delivery Facilities	1,931	34	41	1,942	18.1	3,788,276	0
Vehicle Fleet	759	14	16	764	7.1	3,291,996	0
Transit Fleet	958	6	7	960	9.0	3,843,962	0
Other Process Fugitive	0	0	2,648	56	0.5		
Total	10,605	153	2,960	10,715	100.0	29,412,388	0

Figure 7

Carrboro

Government Greenhouse Gas Emissions in 2009
Report by Source

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Equiv CO_2 (%)	Energy (ekWh)	Cost ($)
Biodiesel (B100)	0	0	0	0	0.0	193,770	0
Diesel	1,216	4	4	1,217	11.4	4,868,660	0
Electricity	7,489	131	157	7,532	70.3	14,547,364	0
Gasoline	502	16	19	507	4.7	2,073,527	0
Methane	0	0	2,648	56	0.5		0
Natural Gas	1,400	3	132	1,403	13.1	7,729,066	0
Total	10,605	153	2,960	10,715	100.0	29,412,388	0

Figure 8

Government Greenhouse Gas Emissions in 2009
Detailed Report

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Equiv CO_2 (%)	Energy (ekWh)	Cost ($)
Buildings and Facilities							
Carrboro, North Carolina							
Century Center (Scope 1)							
Natural Gas	76	0	7	76	0.7	419,898	0
Subtotal Century Center (Sco	76	0	7	76	0.7	419,898	0
Century Center (Scope 2)							
Electricity	212	4	4	213	2.0	411,140	0
Subtotal Century Center (Sco	212	4	4	213	2.0	411,140	0
Fire Department (Scope 1)							
Natural Gas	11	0	1	11	0.1	61,764	0
Subtotal Fire Department (Sc	11	0	1	11	0.1	61,764	0
Fire Department (Scope 2)							
Electricity	120	2	3	121	1.1	233,120	0
Subtotal Fire Department (Sc	120	2	3	121	1.1	233,120	0
Other (Scope 2)							
Electricity	28	0	1	28	0.3	54,866	0
Subtotal Other (Scope 2)	28	0	1	28	0.3	54,866	0
Public Works (Scope 1)							
Natural Gas	12	0	1	12	0.1	68,298	0
Subtotal Public Works (Scop	12	0	1	12	0.1	68,298	0
Public Works (Scope 2)							
Electricity	43	1	1	43	0.4	82,799	0
Subtotal Public Works (Scop	43	1	1	43	0.4	82,799	0
Total Schools (Scope 1)							
Natural Gas	1,289	2	121	1,292	12.1	7,115,945	0
Subtotal Total Schools (Scop	1,289	2	121	1,292	12.1	7,115,945	0

Figure 9

Carrboro

Government Greenhouse Gas Emissions in 2009

Report by Subsector

	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	Equiv CO_2 (tonnes)	Equiv CO_2 (%)	Energy (ekWh)	Cost ($)
Buildings and Facilities							
Carrboro, North Carolina							
Century Center (Scope 1)	76	0	7	76	0.7	419,898	0
Century Center (Scope 2)	212	4	4	213	2.0	411,140	0
Fire Department (Scope 1)	11	0	1	11	0.1	61,764	0
Fire Department (Scope 2)	120	2	3	121	1.1	233,120	0
Other (Scope 2)	28	0	1	28	0.3	54,866	0
Public Works (Scope 1)	12	0	1	12	0.1	68,298	0
Public Works (Scope 2)	43	1	1	43	0.4	82,799	0
Total Schools (Scope 1)	1,289	2	121	1,292	12.1	7,115,945	0
Total Schools (Scope 2)	4,624	81	97	4,651	43.4	8,981,639	0
Town Hall (Scope 1)	1	0	0	1	0.0	5,069	0
Town Hall (Scope 2)	78	1	2	79	0.7	152,370	0
Subtotal Buildings and Facilitie	6,494	92	238	6,527	60.9	17,586,908	0
Streetlights & Traffic S							
Carrboro, North Carolina							
Duke Streetlights (Scope 2)	452	8	9	455	4.2	878,285	0
Piedmont Streetlights Estimate	12	0	0	12	0.1	22,961	0
Subtotal Streetlights & Traffic	464	8	10	467	4.4	901,246	0
Water Delivery Facilitie							
Carrboro, North Carolina							
OWASA (Scope 3)	1,931	34	41	1,942	18.1	3,788,276	0
Subtotal Water Delivery Faciliti	1,931	34	41	1,942	18.1	3,788,276	0
Vehicle Fleet							
Carrboro, North Carolina							
Municipal Transportation (Scop	672	12	14	676	6.3	2,920,777	0
OWASA (Scope 3)	87	2	3	88	0.8	371,219	0
Subtotal Vehicle Fleet	759	14	16	764	7.1	3,291,996	0

Appendix B– Contacts

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