Town of Cary, North Carolina

Inventory of Energy Use and Greenhouse Gas Emissions

Report on Municipal Operations from 2005 to 2010

Prepared by

Brian C. Callaway, MCRP
Research Associate
Institute for the Environment
The University of North Carolina at Chapel Hill
March 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

The author received broad assistance in the generation of this report from a number of contributors. Listed by organization, those involved include the following:

Town of Cary
Emily Barrett
Melanie Bissonnette
Ray Boylston
Kelvin Creech
Larry Dempsey
Chris Duty
Kyle Hubert
Cecil Martin
Chris Parisher
Trish Terreault
Juan Vega

UNC Institute for the Environment
Dr. David McNelis, Ph.D.
Tony Reevy
Dr. Elizabeth Shay, Ph.D.
Dr. Jason West, Ph.D.

Progress Energy
Pat Newton
Chante Woodard

Wake County Schools
Lib McGowan

The Institute for the Environment at the University of North Carolina at Chapel Hill performed this work as part of its distinguished tradition of environmental research and service to communities in North Carolina and around the country.

Emily Barrett, Sustainability Manager at the Town of Cary and the Town Project Manager, provided exceptional assistance throughout this endeavor.

Special acknowledgment must be given to Melanie Bissonnette at Accounts Payable in the Town of Cary Finance Department. Her knowledge, reliability, and alacrity in assistance were invaluable throughout the lengthy process of data acquisition.

Dr. David McNelis, an energy expert, professor and researcher from the Institute for the Environment, lent his support for this project from the day it was conceptualized. His contribution has been much appreciated.

EXECUTIVE SUMMARY

The Town of Cary has the opportunity to save thousands of dollars in municipal energy costs, and this energy and greenhouse gas inventory is the first step toward achieving savings. This report was commissioned by the Town of Cary's Sustainability Manager, Emily Barrett, and funded by the Energy Efficiency and Conservation Block Grant Program (EECBG) of the American Recovery and Reinvestment Act of 2009 (ARRA).

Goals of the EECBG program include:

- reducing fossil fuel emissions and energy use,
- improving energy efficiency, and
- creating and retaining jobs (DOE, 2009).

This report works toward these goals by conducting a detailed inventory of all energy use and greenhouse gas (GHG) emissions resulting from the municipal operations of the Town of Cary. Standard GHG calculation and reporting protocols for local government operations were followed to create this inventory.

Results of this report include the following:

- From 2005 to 2010, municipal energy costs amounted to $43.9 million
- Annual energy costs increased from $5.4 million in 2005 to $8.3 million in 2010 (Figure 1)
- Annual energy costs amounted to an average of $7,206 per employee in 2010, up from $5,237 per employee in 2005
- On-site energy use has increased an average of 8% annually since 2005
- GHG emissions were 43,932 metric tonnes of carbon dioxide equivalent in 2010

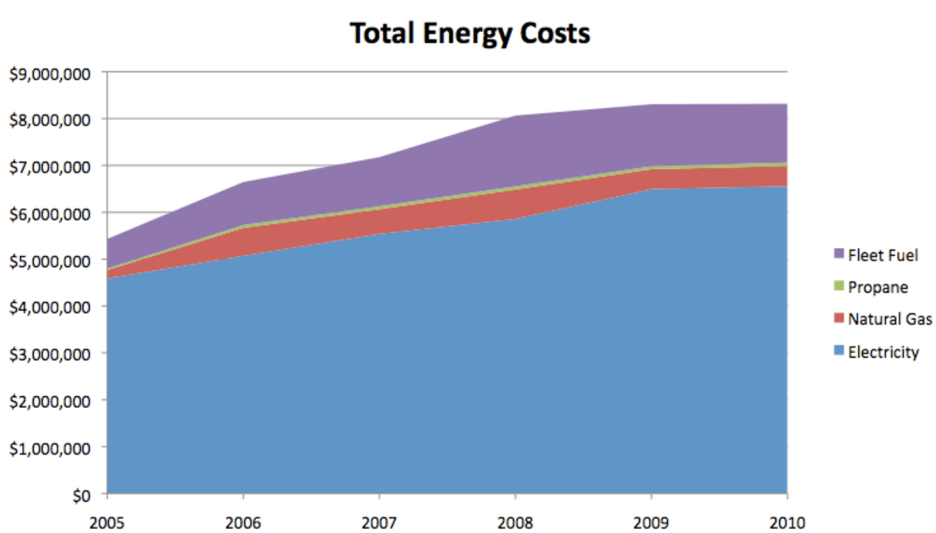


Figure 1: Total Energy Costs, 2005-2010

- GHG emissions have increased an average of 5% annually since 2005
- GHG emissions have risen in every activity sector since 2005 (Figure 2)
- Water and wastewater treatment and delivery represent over 50% of energy use and over 60% of GHG emissions
- Emissions from fleet vehicles have more than doubled since 2005 due to a reported increase in the number of vehicles and equipment, from 333 in 2005 to 681 in 2010

As the adage says, "You cannot manage what you do not measure." Detailed measurement of energy use provided by this inventory is the essential first step in developing an energy management program and strategic energy plan to reduce energy consumption and save money.

From the analysis, the following next steps are recommended for the Town of Cary:

1. Begin an energy management program
2. Create a strategic energy plan
3. Implement a fleet vehicle efficiency policy to guide new vehicle purchases
4. Promote energy literacy throughout the Town

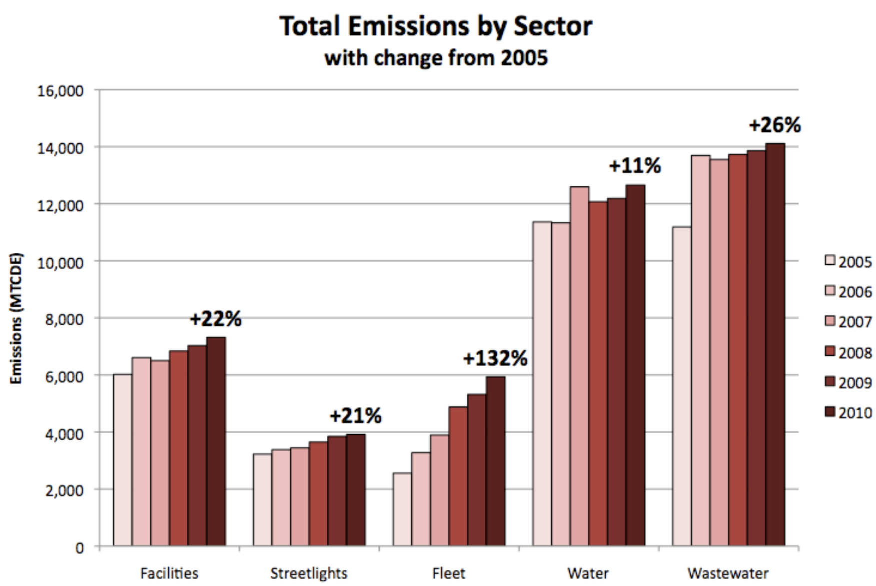


Figure 2: Total GHG Emissions by Activity Sector, 2005-2010

1. INTRODUCTION

This report opens with a description of the general relationship between energy, fossil fuels, and greenhouse gases and establishes a basis for the relevancy of greenhouse gas (GHG) inventories. From there this chapter proceeds to list several ways GHG inventories are valuable before exploring in more detail GHGs and GHG accounting techniques.

Energy, Fossil Fuels, and Greenhouse Gases

The Town consumes energy in a variety of ways. Electricity keeps the lights on; natural gas heats the buildings; and gasoline and diesel power the vehicle fleet. These energy sources have not changed much through the decades. According to the most recent annual report by the U.S. Energy Information Agency (EIA), over 86% of the world's energy needs are met by burning fossil fuels (EIA, 2008). Petroleum tops the list by providing 35.9% of the world's energy, followed by coal (27.4%) and natural gas (22.8%). As world population increases and modernization and electrification expand, the worldwide demand for energy continues to soar. No one can be certain of the size of remaining fossil fuel deposits, but it is true that these fuels are becoming more difficult and expensive to access. Political instability and nationalization of foreign oil wells hinder supplies. Concern about the long-term supply of coal is surfacing in many places around the world. Increasingly more involved and extractive measures such as mountaintop removal, deepwater oil drilling, and shale oil extraction are among acquisition methods adopted recently. These emerging energy trends make managing energy use more relevant than ever.

With 86% of the world's energy derived from fossil fuels, there is a significant amount of fossil fuel combustion occurring across the globe. When fossil fuels are burned, energy (in the form of heat) becomes the desired product, but carbon dioxide is a noteworthy byproduct. Carbon dioxide is a greenhouse gas (GHG), and it traps heat in the atmosphere. (Appendix A describes the effects carbon dioxide and other GHGs have on the earth's climate.) As the world is becoming more concerned about GHG emissions from anthropogenic sources, GHG emission tracking and "carbon footprints" are becoming common and even mandated in places. The main component of GHG accounting involves inventorying all energy consumption and calculating the resulting GHG emissions based on the carbon intensities of each fuel source. As discussed above fossil fuels are the primary sources of energy, but they are becoming more expensive and have become subject to erratic price fluctuations from outside stimuli (Middle East turmoil, hurricanes, market speculation, etc.). On the contrary many renewable energy sources are not subject to the same degree of volatility, and as an added benefit, their use emits either no or low anthropogenic GHGs. Thus, GHG accounting is also a method for energy consumers to measure and understand their reliance on energy from increasingly vulnerable sources (i.e. fossil fuels). In many ways this greenhouse gas inventory could very well be considered an "Energy Risk Assessment Inventory." Over time, the Town can utilize its GHG inventory to track its progress in migrating away from fossil fuels and foreign oil supplies and toward the price stability and national energy independence potentially offered by renewable energy sources.

Value of GHG Emissions Inventories

Considering that conducting a detailed energy inventory is the core of a GHG emissions inventory, there are a plethora of managerial benefits that spill over from the creation of a GHG inventory. Oftentimes, and as in the case of Cary, energy bills are simply budgeted for and paid by finance departments without much further analysis or oversight. Many organizations do not have an energy management strategy that can be used to assess current energy performance, identify opportunities for energy savings, and implement steps towards energy and cost reductions. The measurement of current energy use by the way of this inventory is the first step towards management improvements.

Additional benefits to local governments for performing a GHG inventory include:

1. Providing stakeholder education to management, constituents, and the public
2. Preparing for a carbon constrained future by identifying emission sources so a local government knows the implications of potential regulations
3. Managing risk by documenting early actions to reduce GHG emissions if future regulation is implemented
4. Being recognized as an environmental leader in the region (ICLEI, 2010).

GHG Accounting Details

GHG inventorying continues to be voluntary in most states including North Carolina, but the Environmental Protection Agency (EPA) was ordered to begin regulating GHGs by the U.S. Supreme Court in *Massachusetts v. EPA (2007)*. Even before the ruling, the state of California mandated that all municipalities report GHG emissions on an annual basis. ICLEI—Local Governments for Sustainability, a membership organization of municipalities committed to environmental stewardship, has provided technical assistance to municipalities to assist in mandatory and voluntary GHG reporting. ICLEI has partnered with the California Air Resources Board, California Climate Action Registry, and The Climate Registry to develop a protocol specifically intended for use by municipal governments called *Local Government Operations Protocol, for the quantification and reporting of greenhouse gas emissions inventories, Version 1.1*. The Town elected to utilize this extensive protocol as its standard. All decisions and calculations within this inventory have been made with the guidance provided by this protocol. For more details on the methodology of using this protocol and how it relates to the content of this inventory, see Appendix B. For emissions factors used to derive the results of this report, see the ICLEI protocol available online.

When accounting for GHG emissions, there are two classes of emissions that municipalities can be concerned with: 1) emissions from municipal operations and 2) emissions from the community as a whole. This inventory provides a detailed account of all GHG emissions associated with the municipal operations from the Town (see Appendix B for a list of these activities) and not the wider community. Energy use and emissions from municipal operations are much easier to accurately measure and effectively intervene; thus, these are the primary concern of the Town at this time.

This inventory reports results on the six internationally recognized greenhouse gases regulated under the Kyoto Protocol. Three are naturally occurring and three are synthetic fluorinated gases:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride (SF_6)

Carbon dioxide is the most prevalent of the six greenhouse gases recognized by the Kyoto Protocol. It is formed during all hydrocarbon combustion reactions, which include all fossil fuels. Carbon dioxide results from combustion of gasoline, diesel, natural gas, propane, and coal, each of which are pertinent to the Town's operations.

Within municipal operations methane is emitted from solid waste in landfills and wastewater treatment when anaerobic conditions occur. Methane is also produced in trace amounts in all combustion reactions of fossil fuels. Within municipal operations at the Town of Cary, methane results only in trace amounts from combustion activities.

Nitrous oxide is emitted through the nitrification and denitrification processes of wastewater treatment, from wastewater effluent, by application of fertilizers, and during agricultural soil management practices. Like methane, it is also produced in trace amounts in all combustion reactions of fossil fuels.

The synthetic chemicals used within municipal operations are primarily HFCs as refrigerants in air conditioning and refrigeration systems. PFCs are utilized in industrial processes, and SF_6 is used during electrical transmission and distribution as well as magnesium production. Fugitive emissions result when these synthetic greenhouse gases escape from their intended use during installation leakage, normal operational leakage, and system failures. Even though low volumes are typically emitted, the high global warming potential of these gases can make for substantial emissions equivalents.

Greenhouse gas emissions should not be confused with air pollution from criteria air pollutants. Criteria air pollutants, including nitrogen oxides (NOx), sulfur dioxide, carbon monoxide, ozone, and particulate matter cause acute respiratory illness, smog, acid rain, and other environmental woes. Carbon dioxide and nitrous oxide are inert and pose no direct respiratory or health risks. Methane is not a criteria air pollutant but has been shown to catalyze the formation of ozone.

Each of the greenhouse gases has unique properties and affects global warming to various extents. For instance, methane is 21 times more potent in terms of global warming potential than carbon dioxide over the course of 100 years. In other words, one kilogram of methane gas traps the equivalent amount of atmospheric heat as 21 kilograms of carbon dioxide. Even worse, nitrous oxide traps 310 times as much heat as carbon dioxide, and some of the synthetic chemicals are up to 23,000 times as strong as carbon dioxide. In order to create a meaningful expression of the total emissions of the six greenhouse gases, the measurement standard of "carbon dioxide equivalents" is used. Quantities of non-carbon dioxide GHG emissions are weighted by their global warming potential and are expressed using the conventional GHG reporting standard of metric tonnes of carbon dioxide equivalents (MTCDE). Greenhouse gas accounting utilizes the metric system to establish international continuity in emissions reporting.

Carbon dioxide emissions are calculated by using standard emissions factors corresponding to the relative carbon content of each fuel type. For example, no matter what type of vehicle a gallon of gasoline is combusted in, 8.78 kilogram (kg) of carbon dioxide will result due to the inherent carbon content of gasoline. This figure is 10.21 kg of carbon dioxide for a gallon of diesel. Similar factors exist for natural gas and propane combustion. In the case of electricity, energy is being converted off-site from a raw to a refined form from a fuel resource mix that is not readily known. Because of the interconnectedness of the electrical grid, it is impossible to determine the exact raw energy source used to generate a given kilowatt-hour (kWh) of electricity. The EPA does, however, publish the Emissions and Generation Resource Integrated Database (eGRID) that supplies regional and statewide averages of both emissions and resource mixes. For instance, the most recent update lists North Carolina as generating 61% of its electricity from coal, 31% from nuclear, 3% from natural gas, 2% from hydro and the balance from other sources (EPA, eGRID, 2010). This database also yields emissions rates for carbon dioxide, methane, nitrous oxide, and NOx on a pound-mass per megawatt-hour basis (lb/MWh). Per the ICLEI protocol, the "SRVC" Virginia/Carolinas subregion emission factors are utilized from eGRID2007 for years 2005 and 2006 and eGRID2010 for 2007 to present.

Carbon dioxide is emitted from all combustion reactions, even those of biofuels such as biodiesel, ethanol, wood, and methane collected from biomass. Because these fuels are derived from biological matter that is found within the earth's natural carbon cycle, such as trees and plants, the carbon dioxide emitted from biofuels is biogenic in origin and thus does not contribute to anthropogenic GHG accumulation. Biogenic emissions from biodiesel use do not count as part of the total greenhouse gas emissions for town activities and have been reported separately as an information item. Trace methane and nitrous oxide from the combustion of biofuels is still reported as an anthropogenic GHG source because these trace emissions resulted from combustion, a human activity. The biogenic carbon, however, would have eventually become gaseous carbon dioxide through natural decomposition processes.

In 2010 the Town of Cary emitted 43,932 MTCDE of GHGs from its municipal operations. To put this number into context, these greenhouse gases are equivalent to those that result from average electricity use in 6,385 homes in North Carolina over the course of one year[1] or 7,988 average cars in operation for one year[2]. In order to sequester this quantity of greenhouse gases each year, a 68.6-square-mile forest of southern pines would need to be planted and properly managed (Birdsey, 1996). This area is larger than the Town of Cary's area of 54.0 square miles (OSBM, 2010). Though facts like these can help explain the magnitude of the Town's emissions, the most important aspect of GHG management is to understand current emissions trends and identify opportunities for savings.

---

[1] North Carolina average: 13,488 kWh or 6.9 MTCDE per house per year (EIA, 2010)
[2] National average: 5.5 MTCDE per passenger vehicle per year (EPA, 2005)

2. WEATHER STATISTICS OVER STUDY PERIOD

Since inventories build upon one another from year-to-year and allow comparisons to be made across time, it is important to include information that may impact the integrity of the data each year. Changes happen – operations can be outsourced, data can be mistakenly omitted, and weather can lead to significant changes in annual energy use. Weather correction or normalization is not a component of GHG accounting, but it can provide some explanation for unusual activity.

Heating degree days (HDD) are measured as the difference between the average temperature of each day and a base temperature (65 degrees in most cases) when the average temperature is below the base temperature. Cooling degree days (CDD) are measured in the same way except when the average temperature is above the base temperature. Daily values are summed across the entire year, and the result yields an understanding of roughly how much heating and cooling is needed at a given location during a given year.

The average HDD from 1971 to 2000 was 3,402 as recorded at the Raleigh-Durham International Airport (RDU) by the National Oceanic and Atmospheric Administration (NOAA). Asheville, North Carolina has an annual average of about 4,200; Anchorage, Alaska is 10,470; Miami, Florida is 150. The average CDD from 1971 to 2000 at RDU was 1,560. Asheville has a CDD average of 850; Anchorage is 3; Miami is 4,380 (NOAA, 2001).

Figure 3 indicates that the cold months of calendar year 2009 were slightly warmer than average and calendar year 2010 was the first colder than average year in the last ten years. From this, an increase in the use of heating fuels can be expected in 2010. If possible, selecting a baseline year with near average conditions provides the Town with more complete understanding on the effects of weather and GHG emissions.

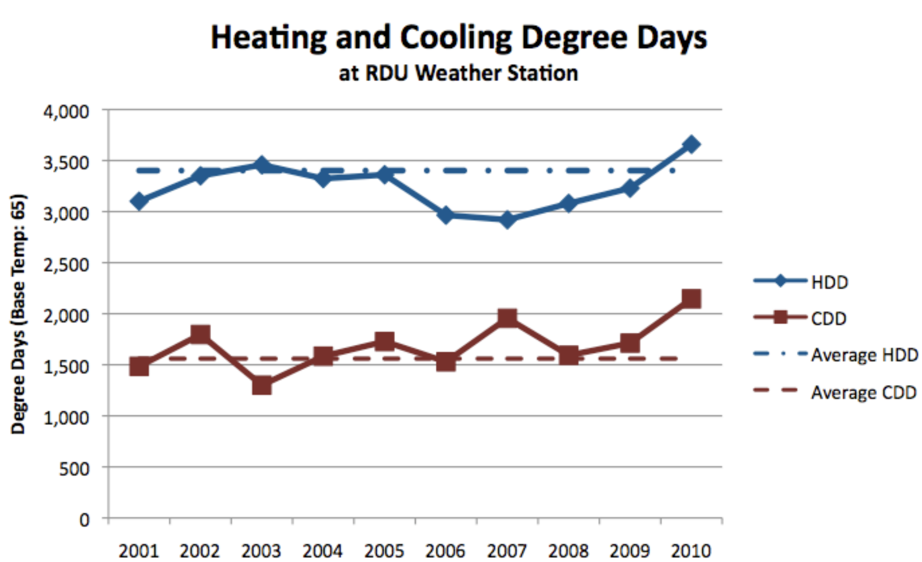


Figure 3: Heating and Cooling Degree Days, 2001-2010

3. RESULTS AND ANALYSIS

Now that this report has introduced GHGs and some details of GHG accounting, this chapter contains a technical presentation of the energy and greenhouse gas inventory results for the Town of Cary. Tables and charts accompany concise explanations of the data and the trends. Data compiled from 2005 through 2010 are presented as annual totals by calendar year as reporting standards call for organizing results by calendar year. Cary has the opportunity to choose which year to distinguish as their baseline, against which to set reduction targets and compare future inventories. At times, this report presents tracked changes since 2005 only to showcase activity trends within all available data.

Energy Use in Overall Municipal Operations

As Table 1 demonstrates, the total cost of energy use among municipal operations has been rising steadily since 2005, reaching $8.3 million in 2010. This figure includes an almost $3 million leap in annual energy expenditures from 2005 to 2010. Electricity costs account for nearly $2 million of that increase over the six-year period. Figure 4 demonstrates this rise and the relative share of each source graphically.

Table 1
Total Energy Costs

By Source	2005	2006	2007	2008	2009	2010
Electricity	$4,587,478	$5,072,279	$5,538,615	$5,857,827	$6,493,483	$6,555,339
Natural Gas	$180,107	$594,993	$526,196	$628,548	$426,725	$433,387
Propane	$31,752	$59,947	$63,751	$66,811	$62,652	$72,525
Fleet Fuel	$631,710	$919,346	$1,048,516	$1,510,306	$1,323,534	$1,254,149
TOTAL	$5,431,047	$6,646,565	$7,177,078	$8,063,493	$8,306,394	$8,315,400

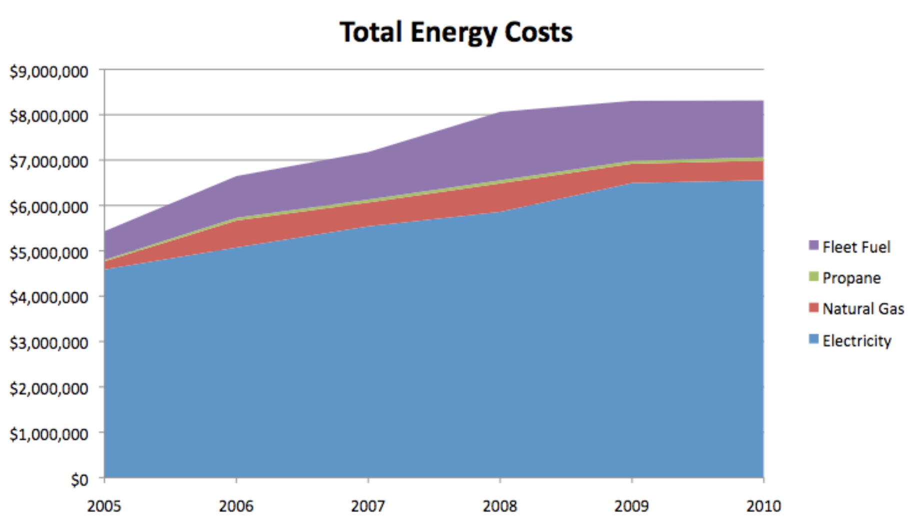


Figure 4: Total Energy Costs, 2005-2010

Evaluating total costs only tells the financial segment of the story. From this information alone, it cannot be determined whether costs are increasing because of rising energy prices, rising energy use, or both. Energy and GHG inventories take the extra step to analyze energy consumption and energy sources. Table 2 exhibits the total on-site energy use by each source, listed by its unique unit of measure.

Table 2
On-Site Energy Use

By Source	Unit	2005	2006	2007	2008	2009	2010
Electricity	kWhs	58,761,037	61,430,184	64,565,493	64,908,939	66,175,202	67,759,011
Natural Gas	therms	179,629	508,747	493,821	496,746	493,660	543,667
Propane	gallons	10,269	20,958	23,231	20,661	21,012	23,506
B20 Biodiesel	gallons	150,053	211,212	252,013	290,219	335,559	366,456
Gasoline	gallons	149,861	174,876	207,106	277,780	284,148	326,965

In order to gain a sense of how much total energy the Town uses, Table 3 expresses energy use in a unit of measure for energy, the British thermal unit (Btu). Results have been converted to million-Btus (MMBtu). Annual totals can now be compared to one another. Figure 5 demonstrates a trend similar to that of energy costs with just a few anomalies. Natural gas use has remained relatively constant though its cost has decreased, which is confirmed by the lower per unit prices currently in the natural gas market. Figure 5 shows fairly stable fleet fuel costs the last few years, but Figure 5 reveals that actual fleet fuel use has been growing. There have been lower per unit costs since the fuel price spike of 2008.

Table 3
On-Site Energy Use (MMBtu)

By Source	2005	2006	2007	2008	2009	2010
Electricity	200,501	209,609	220,307	221,479	225,799	231,203
Natural Gas	17,963	50,875	49,382	49,675	49,366	54,367
Propane	935	1,907	2,114	1,880	1,912	2,139
Fleet Fuel	39,151	50,600	60,181	74,214	81,180	90,737
TOTAL	258,550	312,991	331,984	347,248	358,258	378,446

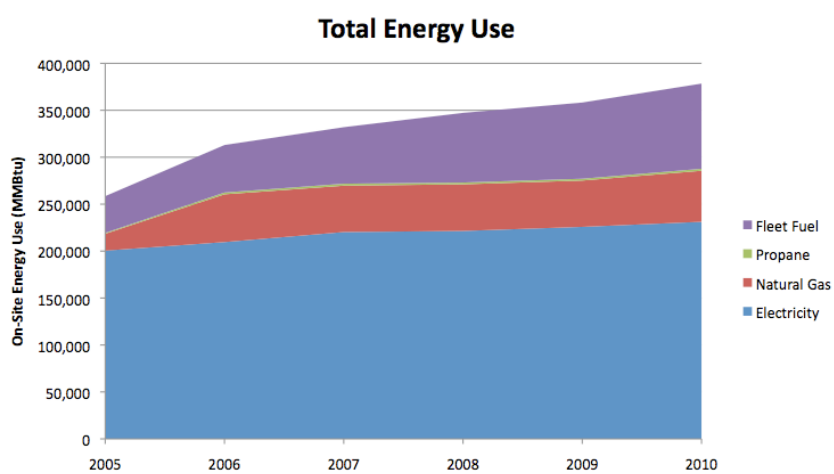


Figure 5: Total Energy Use, 2005-2010

Figure 6 and Table 4 show the Town's overall energy use profile across municipal operations. It is clear that the majority of on-site energy use in Cary is from electricity; however, as Table 5 demonstrates, fleet fuel has resulted in the most consistent year-to-year growth in energy consumption since 2005. Among natural gas use, the significant increase from 2005 to 2006 is explained by the opening of the biosolids dryer at the South Cary Water Reclamation Plant as 2006 was its first full year of operation. Increased natural gas and propane use in 2010 is likely due to a colder than average winter.

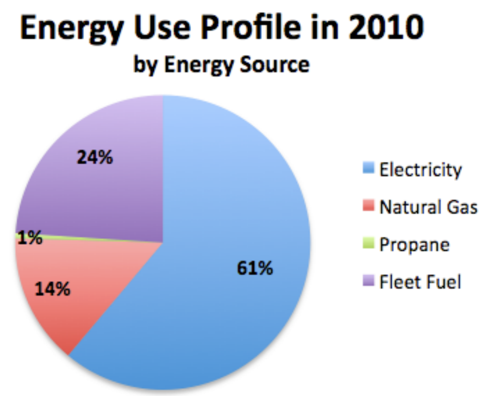


Figure 6: Energy Use Profile by Source, 2010

Table 4
On-Site Energy Use Share (% of Total)

Share By Source	2005	2006	2007	2008	2009	2010
Electricity	78%	67%	66%	64%	63%	61%
Natural Gas	7%	16%	15%	14%	14%	14%
Propane	0%	1%	1%	1%	1%	1%
Fleet Fuel	15%	16%	18%	21%	23%	24%

Table 5
Year-to-Year Change in On-Site Energy Use (%)

By Source	2005	2006	2007	2008	2009	2010
Electricity	-	5%	5%	1%	2%	2%
Natural Gas	-	183%	-3%	1%	-1%	10%
Propane	-	104%	11%	-11%	2%	12%
Fleet Fuel	-	29%	19%	23%	9%	12%

Electricity use occurs from nearly 300 unique accounts spread throughout the town and is served by Progress Energy (250+ accounts), Duke Energy (8 accounts), and the Town of Apex Utilities (5 accounts). As Figure 7 demonstrates, water and wastewater treatment processes, including treatment and delivery, used the majority of electricity. Outdoor

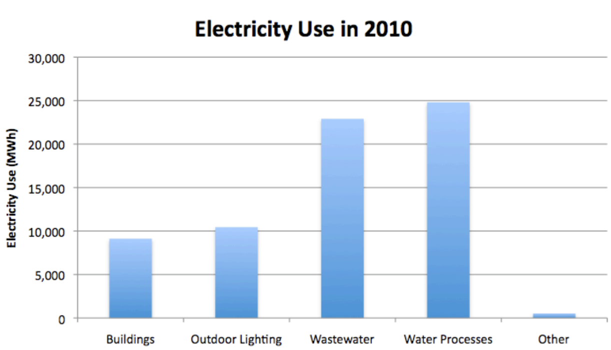


Figure 7: Emissions from Electricity by End Use, 2010

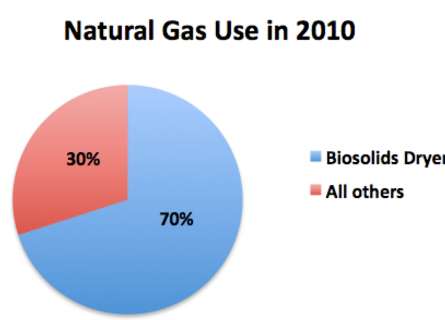


Figure 8: Natural Gas Use, 2010

lighting in the form of streetlights, sport lighting, parking lot lighting, and traffic-related signals and signs accounted for slightly over 10,000 megawatt-hours (MWh) of usage in 2010. Buildings used just under 10,000 MWh in 2010. Natural gas is used in 20 town buildings for space heating and/or domestic hot water. As Figure 8 shows, natural gas usage at the biosolids dryer at the South Cary Water Reclamation Plant represented 70% of all natural gas use in 2010. Propane use occurs primarily at the James Jackson complex that houses a number of operations from various divisions including Public Works and Utilities, Purchasing, and some Human Resources. Fleet fuel is consumed in the town vehicle fleet. Chapter 4 contains more information on the usage of fleet fuel

GHG Emissions in Overall Municipal Operations

Standard GHG emissions factors based on the carbon content of each fuel source are applied to energy data to calculate GHG emissions totals. Table 6 lists the GHG emissions by source.

Table 6
Total Greenhouse Gas Emissions (MTCDE)

By Source	2005	2006	2007	2008	2009	2010
Electricity	30,425	31,807	32,941	33,116	33,762	34,570
Natural Gas	956	2,706	2,627	2,642	2,626	2,892
Propane	58	118	131	117	119	133
Fleet	2,556	3,276	3,893	4,828	5,255	5,885
Wastewater Process	358	382	386	407	420	402
HFC Fugitives	0	0	0	51	63	50
TOTAL	34,353	38,291	39,978	41,161	42,244	43,932
Annual Change		11.5%	4.4%	3.0%	2.6%	4.0%

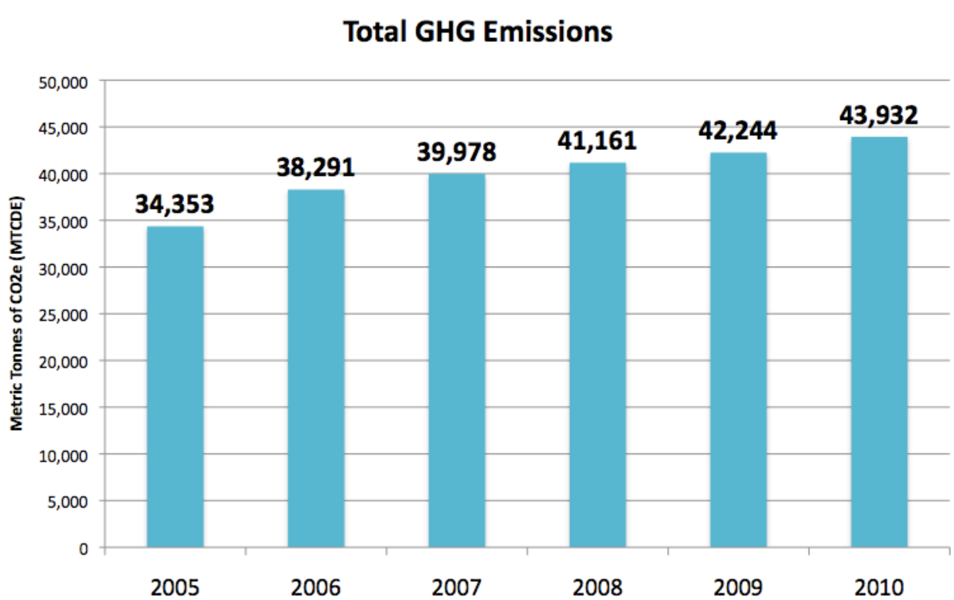


Figure 9: Total GHG Emissions, 2005-2010

In addition to emissions from energy sources, greenhouse gases are also directly released from two non-combustion sources. Small amounts of nitrous oxide emissions escape during the nitrification and denitrification steps of wastewater treatment and also from the nitrogen content of the effluent. Those emissions comprise the "Wastewater Process" emissions. "HFC Fugitives" arise from direct hydrofluorocarbons that leak from refrigeration units. These escaping gases were estimated from the Fleet Division HFC purchase history for recharging air conditioning systems in town vehicles.

From 2005 to 2006, total emissions rose 11.5% due mainly to the opening of the biosolids dryer. Since then, total emissions have risen an average of 3.5% annually.

Table 7 and Figure 10 show the profile of emissions by source. Electricity is by far the largest source of emissions. Table 4 above established that electricity accounted for approximately 61% of the Town's on-site energy use, while Table 7 demonstrates electricity accounts for 79% of all emissions. This emissions-energy ratio—79% of emissions to 61% of energy—demonstrates the high fossil fuel intensity of electricity compared to the other fuels used in town. If our state's utility companies were to use less carbon-intensive fuel sources, this emissions-energy gap would not be as large.

Table 7
Emissions Share (% of Total)

By Source	2005	2006	2007	2008	2009	2010
Electricity	89%	83%	82%	80%	80%	79%
Natural Gas	3%	7%	7%	6%	6%	7%
Propane	0%	0%	0%	0%	0%	0.3%
Fleet	7%	9%	10%	12%	12%	13%
Wastewater Process	1%	1%	1%	1%	1%	1%
HFC Fugitives	0%	0%	0%	0%	0%	0.1%

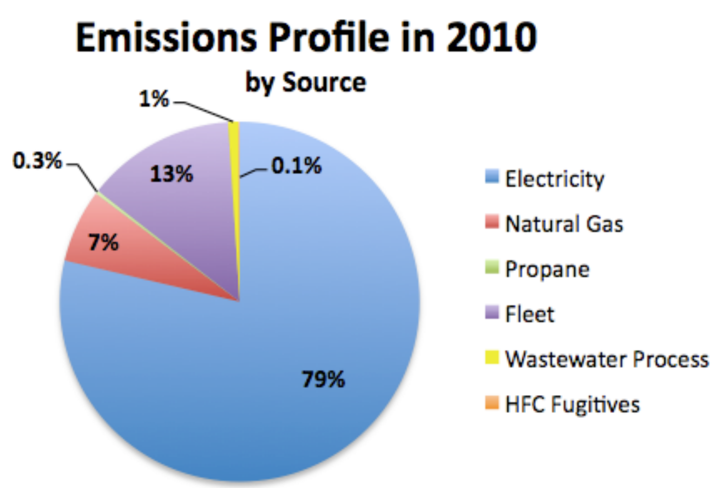


Figure 10: Emissions Profile by Source, 2010

Table 8 below reports overall emissions totals, listed by greenhouse gas in both total emissions rates in metric tonnes of each gas per year and in terms of MTCDE of each gas per year. Nitrogen oxides (NOx), though not a greenhouse gas, have been inventoried as well. See Chapter 6 for more details.

Because the fleet vehicles use a 20% biodiesel blend ("B20") consisting of 20% diesel that has been produced from non-fossil fuel sources, there are additional carbon dioxide emissions that are not counted as part of the greenhouse gas emissions. These are identified as biogenic carbon dioxide emissions and are listed as an information item.

Table 8
Emissions Totals

By Pollutant	2005	2006	2007	2008	2009	2010
CO2 (metric tonnes)	33,801	37,700	39,381	40,489	41,543	43,254
CH4 (metric tonnes)	0.78	0.99	0.98	1.00	1.01	1.07
N2O (metric tonnes)	1.73	1.84	1.86	1.94	1.99	1.95
HFC-134a (kg)	0	0	0	39	48	38
MTCDE from CO2	33,801	37,700	39,381	40,489	41,543	43,254
MTCDE from CH4	16	21	21	21	21	22
MTCDE from N2O	536	570	577	600	617	605
MTCDE from HFCs	0	0	0	51	63	50
NOx (kg)	56,774	61,001	55,710	58,811	61,904	65,439
Biogenic CO2 (MTs)	284	399	476	549	634	693

Energy and Emissions by Activity Sector

Energy use and GHG emissions have been subdivided by activity sector to yield a better understanding of the Town's energy and emissions profile. The activity sectors selected that best correspond to the municipal operations of the Town of Cary include facilities, streetlights, fleet vehicles, water treatment and delivery ("water"), and wastewater treatment and processes ("wastewater"):

- Facilities -all buildings, parks and ballfields, lighting associated with those facilities, and leased spaces such as Middle Creek Community Center.
- Streetlights - all streetlights, traffic signals, traffic signs, and traffic cameras.
- Fleet vehicles - all vehicles owned and operated by the Town of Cary. Cary's public transportation, C-Tran, is also listed as a subset of the fleet vehicles because the Town exerts operational control even though a private organization actually operates the vehicles (see Appendix B for a detailed explanation of this and all accounting decisions).
- Water - water treatment and delivery stations.
- Wastewater - wastewater treatment and delivery stations.

Table 9 and Figure 11 show an overview of the emissions from each activity sector since 2005. For more details on the trends within each activity sector over the course of this study, please see Chapter 4.

Table 10 shows that over the entire study period, emissions from the water and wastewater sectors have represented nearly two-thirds of the Town's total emissions each year. Every sector has experienced growth in emissions, but the fleet sector is the only one that has seen its share of total emissions grow, which is a testament to how extreme has been the increase of emissions in that sector.

Table 9
Total Emissions (MTCDE)

By Sector	2005	2006	2007	2008	2009	2010
Facilities	6,021	6,608	6,499	6,838	7,029	7,317
Streetlights	3,226	3,382	3,443	3,648	3,848	3,915
Fleet	2,556	3,276	3,893	4,879	5,318	5,934
Water	11,363	11,332	12,594	12,071	12,188	12,655
Wastewater	11,188	13,692	13,549	13,726	13,862	14,111
TOTAL	34,353	38,291	39,978	41,161	42,244	43,932

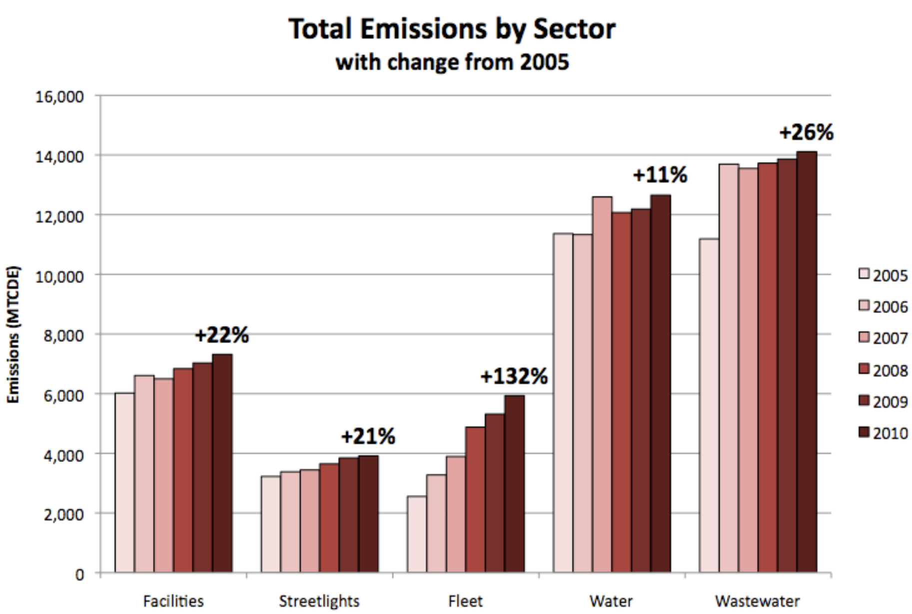


Figure 11: Total GHG Emissions by Sector, 2005-2010

Table 10
Emissions Share (% of Total)

By Sector	2005	2006	2007	2008	2009	2010
Facilities	18%	17%	16%	17%	17%	17%
Streetlights	9%	9%	9%	9%	9%	9%
Fleet	7%	9%	10%	12%	13%	14%
Water	33%	30%	32%	29%	29%	29%
Wastewater	33%	36%	34%	33%	33%	32%

Table 11 has combined all the various energy inputs (kWhs of electricity, therms of natural gas, and gallons of propane, gasoline and biodiesel) into the conventional MMBtu units for each activity sector. Figures 12 and 13 display side-by-side comparisons of the energy profile and emissions profile by activity sector. Because electricity is a more carbon intensive energy source, there is not a perfectly congruent relationship between the energy share and the emissions share, as Table 12 shows.

Table 11
On-site Energy Use

By Sector	Unit	2005	2006	2007	2008	2009	2010
Facilities	MMBtu	48,739	53,997	52,275	55,881	57,817	60,691
Streetlights	MMBtu	21,257	22,288	23,030	24,396	25,732	26,180
Fleet	MMBtu	39,151	50,600	60,181	74,214	81,180	90,737
Water	MMBtu	74,878	74,674	84,224	80,728	81,510	84,633
Wastewater	MMBtu	74,524	111,431	112,274	112,028	112,019	116,205

Table 12
Emissions and On-Site Energy Share in 2010

By Sector	Emissions	On-Site Energy Use
Facilities	17%	16%
Streetlights	9%	7%
Fleet	14%	24%
Water	29%	22%
Wastewater	32%	31%

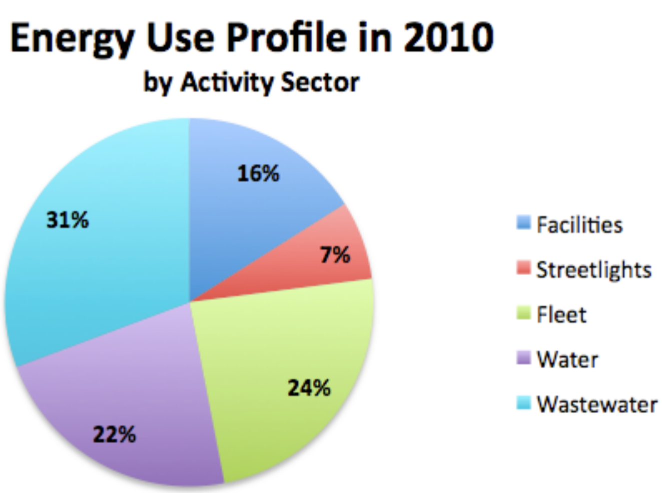


Figure 12: Energy Use Profile by Sector, 2010

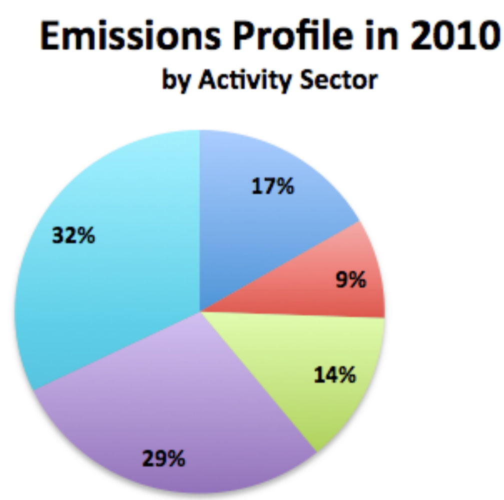


Figure 13: Emissions Profile by Sector, 2010

Source Energy and GHG Emissions

Electricity is unlike the other energy forms used by the Town in municipal operations. Natural gas, propane, gasoline, and diesel fuel are raw fuels that are combusted on-site for energy use. Electricity is a converted energy form—one that is produced off-site and purchased from a utility company. When the Town burns a raw fuel, the Town absorbs the inefficiencies of the energy transfer. Inefficiency is always present during energy transfer, but some methods convert stored energy into mechanical and/or thermal energy more efficiently than others. The EPA estimates only 12.6% of the energy potential of a gallon of transportation fuel is transferred to the drivetrain (EPA, 2011). Natural gas efficiency rates depend on many factors but current units on the market range in annual fuel utilization efficiency from near 80% up to 96% (ACEEE, 2011). In 2007 coal-fired power plants were measured to have 32% efficiency on average (NETL, 2008). These inefficiencies are not particularly noticeable by users because they have already developed performance expectations: a 20 mile-per-gallon car is expected to travel 20 miles per gallon, even though it could travel twice as far if an engine were twice as efficient.

This efficiency relationship becomes especially pertinent to building performance measurements because electricity, as a converted fuel, is delivered after some other entity has absorbed the inefficiencies involved in generation, transmission, and delivery of electricity. Oftentimes, buildings are rated on a thousand-Btu per square foot (kBtu/sf) basis where kBtu is the measurement of energy *delivered* to the building. Measuring total energy only as delivered or "on-site" energy use is such a common measurement that up to this point this document has presented energy use as the on-site usage (the sum of raw fuel and converted energy). However, raw fuel and converted energy are not directly comparable. In order to more accurately compare the actual amount of raw energy used in operations, the national average source-site ratio for each energy source is presented in Table 13 (EPA, 2011). It can be seen that both the relative carbon intensity and the site-source ratio of electricity are notably higher than the other fuels. Table 14 on the next page applies these site-source ratios across each activity sector and measures the total energy consumed, both on-site and off-site, from raw energy sources.

Table 13
Carbon Intensity and Site-Source Ratios of Energy Sources

Source	kg anthropogenic CO2e/MMBtu	Site-Source Ratios (2007)
Electricity	149.5	3.334
Natural Gas	53.2	1.047
Propane	62.0	1.01
B20 Biodiesel	60.0	1.01
Gasoline	70.2	1.01

Table 14
Source Energy Use (MMBtu)

By Sector	2005	2006	2007	2008	2009	2010
Facilities	130,563	142,994	142,711	150,044	154,176	160,350
Streetlights	70,998	74,443	76,919	81,484	85,944	87,441
Fleet	39,543	51,106	60,783	74,956	81,992	91,644
Water	250,093	249,413	281,309	269,632	272,242	282,672
Wastewater	237,770	288,436	288,724	292,486	295,425	300,839
TOTAL	728,967	806,391	850,446	868,603	889,779	922,946

The connection of greenhouse gas emissions to energy is further exemplified by the results of Table 15. As mentioned earlier in this document, greenhouse gas inventories are essentially means by which to measure the fossil fuel content of an energy stream. Comparing emissions and "on-site" or delivered energy as in Table 12 shows that although there is a relationship between the two, measured on-site energy uses do not take into account the substantial energy losses during electricity generation and transmission. Table 15 demonstrates that the GHG emissions count corresponds far more accurately with the source energy use since it does take into account the energy used to generate converted energy forms.

Table 15
Emissions and Source Energy Use Share in 2010

By Sector	Emissions	Source Energy Use
Facilities	17%	17%
Streetlights	9%	9%
Fleet	14%	10%
Water	29%	31%
Wastewater	32%	33%

Trends in Cost, Use, and GHG Emissions

The greatest value in performing a multi-year energy and emissions inventory is that trends can be identified and used to improve efficiency. Table 16 shows the year-to-year percentage change in emissions within each activity sector with the most recent trends, the change from 2009 to 2010, highlighted by the box.

Table 16
Year-to-Year Change in Emissions (%)

By Sector	2005	2006	2007	2008	2009	2010
Facilities	-	9.8%	-1.7%	5.2%	2.8%	4.1%
Streetlights	-	4.9%	1.8%	5.9%	5.5%	1.7%
Fleet	-	28.2%	18.8%	25.3%	9.0%	11.6%
Water	-	-0.3%	11.1%	-4.2%	1.0%	3.8%
Wastewater	-	22.4%	-1.0%	1.3%	1.0%	1.8%
TOTAL	-	11.5%	4.4%	3.0%	2.6%	4.0%

Table 17
Change in Cost, Energy, Emissions from 2005 (%)

	2005	2006	2007	2008	2009	2010
Cost	-	22%	32%	48%	53%	53%
Energy Use	-	21%	28%	34%	39%	46%
Carbon Emissions	-	11%	16%	20%	23%	28%

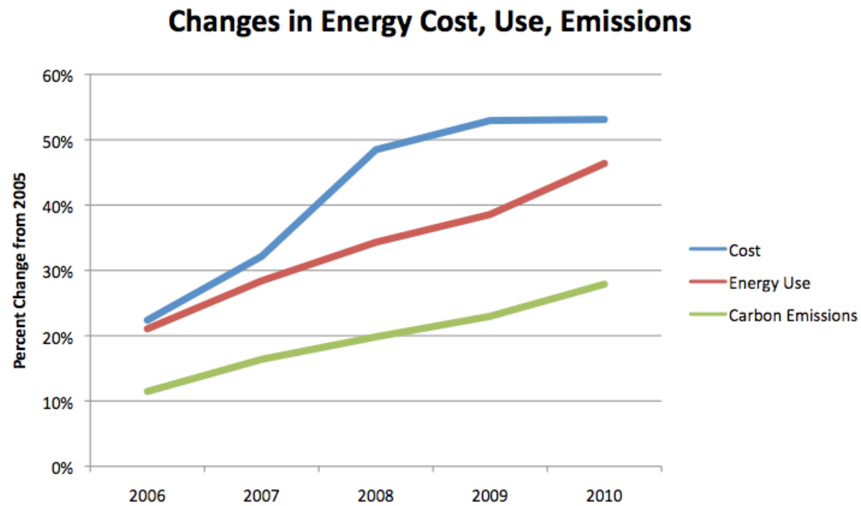


Figure 14: Changes in Cost, Energy Use, and Emissions

Energy costs, energy use, and emissions have all been measured and compared to their 2005 levels in Table 17 and Figure 14. The graph demonstrates that energy costs have outpaced energy use, which means that per unit energy prices have increased over this time frame. The energy price spikes of 2008 are evidenced by the rapid upward trend of the energy cost curve, followed by a leveling out as energy prices dropped over 2009 and 2010. Town energy use still increased during this time (Table 18), resulting in a level energy cost curve instead of a downward trend that would have been seen had energy consumption stabilized. Total emissions, though increasing by 28% since 2005, have increased at a slower pace than energy consumption. This is because less carbon-intensive energy sources, namely the biosolids dryer natural gas use and fleet vehicle use, have grown faster than the more carbon-intensive electricity use. If natural gas and transportation fuel represent larger shares of the Town's energy mix, emissions will continue to track lower than energy use. To maximize cost savings, it is desirable to see all three of these curves trend downward.

Table 18
Change in Cost, Energy, Emissions from 2009 (%)

	2010
Cost	0.1%
Energy Use	5.6%
Carbon Emissions	4.0%

Energy costs have been for the most part falling slightly from highs in 2008. As the recession ends, demand and subsequent prices are expected to increase again. These costs are displayed as dollar per MMBtu of delivered energy and do not take into account the source energy lost in generation, transmission, and delivery. It is interesting to point out that electricity is 3.5 times more expensive than natural gas, which is very similar to and explained by its site-source ratio of 3.34. Propane has tremendous costs associated with it, as it is handled and delivered in small quantities by a local vendor.

Table 19
Energy Costs per MMBtu ($/MMBtu)

Source	2005	2006	2007	2008	2009	2010
Electricity	$23	$24	$25	$26	$29	$28
Natural Gas	$10	$12	$11	$13	$9	$8
Propane	$34	$31	$30	$36	$33	$34
Fleet Fuel	$16	$18	$17	$20	$16	$14

Table 20
Other Emissions Metrics

Metric	2005	2006	2007	2008	2009	2010
Population	113,251	119,745	127,640	134,208	139,110	143,049
Emissions per capita	0.303	0.320	0.313	0.307	0.304	0.307
Employee Count (FTEs)	1,037.125	1,063.25	1,095.125	1,129.375	1,157.75	1,153.875
Emissions per employee	33.12	36.01	36.51	36.45	36.49	38.07

Table 20 presents emissions, population, and the employee count of the Town as well as the mixed metrics of emissions per capita and emissions per employee. When looking at Figure 15 that plots the changes in values from 2005, emissions growth and population growth have mostly mirrored one another while both outpaced the growth in town employees. (The flattening of the employee curve from 2009 and 2010 reflects the hiring freezes that most municipalities put in place during the recession.) Combining the

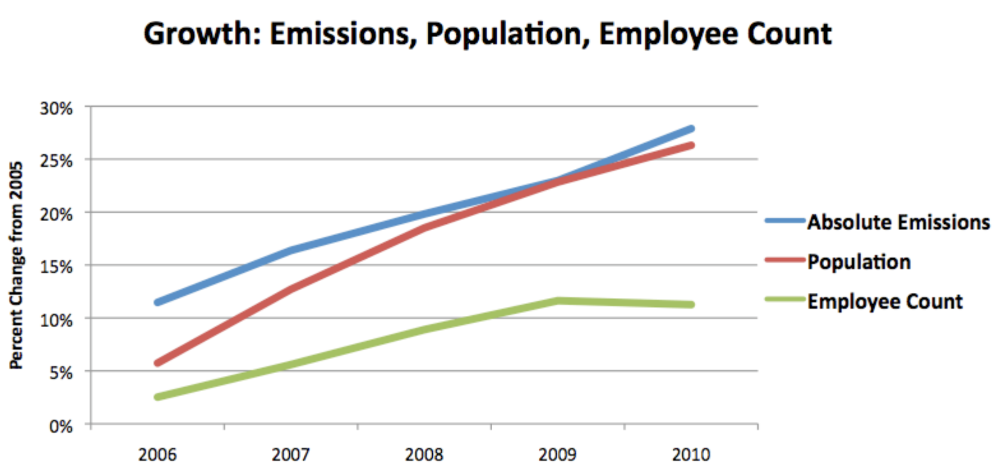


Figure 15: Growth, 2006-2010

population and employee growth trends with emissions growth to create mixed metrics can distort the overall trends by measuring two mostly independent metrics, as demonstrated in Figure 16. If emissions per capita decrease, as they have since 2006, this could be due to decreasing emissions or from an increasing population. In Cary's case, the growth in population since 2006 has outpaced the growth in emissions. This means the emissions per capita has fallen, but total emissions have still increased. If carbon emissions were taxed, the tax expenditure by the Town still would increase. The emissions per employee metric had been very stable from 2006 to 2009 but then suddenly trended upward sharply in 2010. Just by looking at the metric, it is difficult to tell whether this increase is due to cutting employees or from an increase in emissions. In this case, both contributed. The point is that mixed metrics can be an informative item, but policy should never be attached to a mixed emissions metric because there could easily be unintended means used to accomplish a stated result.

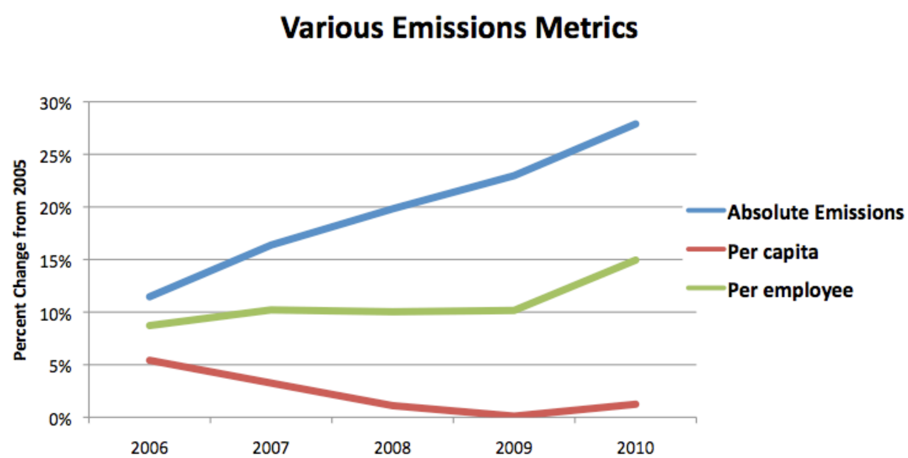


Figure 16: Various Emissions Metrics, 2006-2010

GHG Emissions Forecast

In this report, GHG emissions are forecasted to the year 2020 by applying an average annual growth rate of 3.5%. As Table 6 showed, emissions grew by 11.5% from 2005 to 2006 mostly from the addition of the biosolids dryer. Growth slowed to an average of 3.5% annually between 2006 and 2010. Assuming that the same trends experienced during this 5-year period remain in place for the next 10 years, total emissions of municipal operations from the Town of Cary will reach nearly 62,000 MTCDE by 2020, as demonstrated by Figure 17. (For the purposes of the graph, the baseline was arbitrarily selected as 2009 only to serve as a point of reference.)

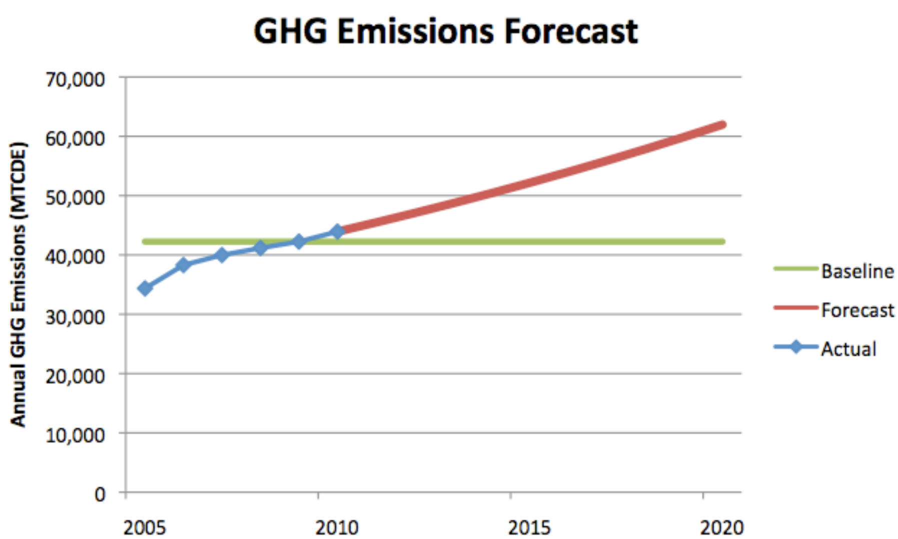


Figure 17: GHG Emissions Forecast, 2005-2030

4. GHG EMISSIONS IN DETAIL

This chapter provides additional tables and explanations of energy and emissions activities within each activity sector and among departments of the Town. The department section is merely an introduction to departmental reports compiled as dashboard style report cards in Appendix D.

Activity Sectors in Detail

FACILITIES: The majority of emissions from the facilities sector are from electricity use in buildings—a stock that measured roughly 480,000 square feet in 2010. Electricity use represented 86% of emissions in facilities, natural gas 12%, and propane 2%. Among electricity use in facilities in 2010, 74% of emissions came from buildings, 17% from sport lighting, and 5% from other outdoor lighting. Given the significant share of emissions from buildings, Tables 21 lists the ten most energy-intensive buildings by kBtu per square foot of delivered energy, and Table 22 lists the top ten buildings by overall GHG emissions.

Table 21
Most Energy Intensive Buildings in 2010

Building	Square Feet	Site Energy KBtu/sqft	Source Energy KBtu/sqft
Town Hall B	55,226	208.3	488.9
Town Hall C	52,951	169.0	430.8
North Cary Water Reclamation Office Building	9,200	168.7	563.3
Bond Park Senior Center	17,500	155.5	415.3
Middle Creek Park Ball Tower	5,612	146.6	489.6
Cary Tennis Center	5,897	121.1	404.5
Jordan Hall Arts Center	5,550	116.7	301.1
Bond Park Community Center	29,500	110.4	290.7
Fire Station #4	7,200	109.2	244.2
Public Works and Utilities Operation Center	31,253	106.7	290.2

Table 22
Highest GHG Totals Among Buildings in 2010

Building	Square Feet	MTCDE	MTCDE/1000sf
Town Hall B	55,226	1,240	22.5
Town Hall C	52,951	1,041	19.7
Town Hall A	48,945	442	9.0
Public Works and Utilities Operation Center	31,253	421	13.5
Bond Park Community Center	29,500	390	13.2
Bond Park Senior Center	17,500	330	18.9
Herb Young Community Center	26,700	237	8.9
NCWRF- Office Building	9,200	232	25.2
Fleet Building	13,240	165	12.4
Middle Creek Park Ball Tower	5,612	123	21.9

STREETLIGHTS: The streetlights activity sector includes streetlights, traffic signals, traffic signs, and traffic cameras that only use electricity as their energy source. Energy use in streetlights accounts for 99.1% of the sector's emissions totals, so Table 23 includes a historic bulb count and kWh estimate. The bulb count roughly parallels the kWh totals. Utilities do not meter streetlight activity and instead include a kWh energy use estimate for each bulb type in the terms of the light contract. Because bulbs have a number of different wattages, the growth in total kWhs only roughly parallels growth in the bulb count.

Table 23
Streetlight Count

	2005	2006	2007	2008	2009	2010
Total Bulb Count	7,439	7,717	7,802	8,220	8,402	8,462
Annual % Change	-	3.7%	1.1%	5.4%	2.2%	0.7%
Total kWh in Sector	6,229,747	6,532,029	6,749,332	7,149,868	7,541,195	7,672,603
Annual % Change	-	4.9%	3.3%	5.9%	5.5%	1.7%

FLEET: Over the six-year study period, the vehicle fleet has more than doubled in size from 333 vehicles and large, non-road equipment pieces (2005) to 681 vehicles and large equipment pieces (2010). Some of this growth results from the reabsorption of several activities that were previously contracted out, such as waste hauling. However, other programs such as recycling collection simply have expanded[1]. Nonetheless, the degree of growth seen in this activity sector is either just extremely high or an error due to inadequate historical data. The fleet division was queried on this issue but offered no feedback, so the data received have been accepted as accurate for the purposes of this report. Table 24 includes details of the fleet energy use and total emissions.

Table 24
Fleet Sector Emissions Statistics

	2005	2006	2007	2008	2009	2010
Fleet Emissions (MTCDE)	2,556	3,276	3,893	4,879	5,318	5,934
B20 Use (gals)	150,053	211,212	252,013	290,219	335,559	366,456
Gasoline Use (gals)	149,861	174,876	207,106	277,780	284,148	326,965
Total FY Cost ($)	$631,710	$919,346	$1,048,516	$1,510,306	$1,323,534	$1,254,149
Vehicle Count (#)	333	397	471	554	609	681
Biogenic CO2 (tonnes)	284	399	476	549	634	693

Unfortunately, the fleet data also had severe errors from the input of erroneous odometer readings. This recorded annual utilization to range from negative 250,000 miles in one year to up to 500,000 miles, both of which are unmistakably errors. This forced the removal of almost 10% of all fleet mileage data and severely hindered accurate tracking of miles per gallon (MPG) and total vehicle miles, two very useful indicators within a fleet. Not only does incorrect data affect a fleet analysis, but the institutional acceptance of these practices can easily lead to unaccounted and untraceable fuel disbursements.

---

[1] The Town of Morrisville contracts the Town of Cary to manage their fleet vehicles, and those vehicles have been properly discarded from the Town of Cary's fleet data.

Also note that vehicle counts included all vehicles that had activity records within a given calendar. If a vehicle was purchased as a replacement for another vehicle, both vehicles were counted unless the replacement occurred exactly on December 31 or January 1.

Since mileage data are unavailable, the next best metric to use is vehicle counts by vehicle type. As demonstrated by Figure 18, the most common vehicle type in the fleet is the light-duty gasoline truck. Heavy-duty diesel trucks, though accounting for only 17% of the composition of the fleet, represent 33% of the total emissions. Increasing the fuel efficiency of heavy-duty equipment represents a significant reduction opportunity in most municipal fleets. Oftentimes among heavy-duty equipment, a 10% fuel efficiency gain might mean only a 0.3 MPG improvement that can be accomplishable through anti-idling campaigns, strict maintenance practices, or after-market retrofit kits.

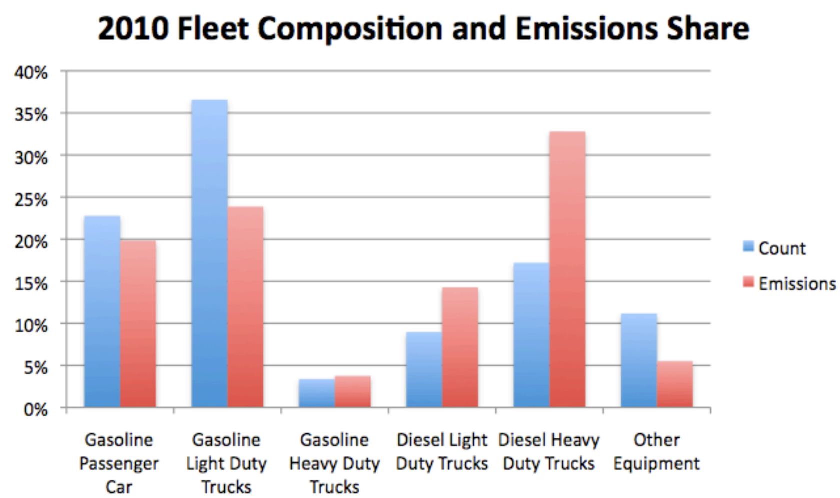


Figure 18: Fleet Composition and Emissions Share, 2010

Activity from Cary's transit provider, C-Tran, is included in the fleet totals and presented as a subset of data in Table 25. Mileage information from the transit vehicles was of poor quality and was therefore completely disregarded, so only fuel use records were used for this analysis. With the introduction of many new gasoline vehicles, an item of interest in future inventories could be to track the performance and GHG emissions of the new vehicles compared to the existing vehicles.

Table 25
Transit Emissions Statistics

	2005	2006	2007	2008	2009	2010
Transit Emissions (MTCDE)	349	599	630	659	801	923
B20 Use (gals)	28,721	60,410	61,126	60,987	73,768	65,933
Gasoline Use (gals)	12,941	11,863	14,750	18,151	22,386	43,511
Vehicle Count (#)	20	29	27	28	36	59
Biogenic CO2 (tonnes)	54	114	116	115	139	125

WATER: Emissions from water treatment and delivery, as expected, mirror the trends of the volume of water treated. Increases in emissions in 2007 correspond with increases in the volume of water delivered, and decreases in emissions followed less usage during the 2008 drought. All energy used in the water sector is from electricity use (with the exception of one very small natural gas account). The Cary/Apex Water Treatment Plant accounted for 58% of the water sector's energy use and emissions in 2010. The water intake plant accounted for 23%, and energy use at other pump stations across town made up the other 19%. Even though the cost of the plant is shared with Apex, the Town of Cary operates the plant and therefore is responsible for reporting its emissions. Table 26 shows specific water sector data including the proposed performance indicator of MTCDE per million gallons (MG) of treated water.

Table 26
Water Sector Emissions

	2005	2006	2007	2008	2009	2010
Volume of Water Treated (MG)	5,695	5,672	6,712	6,066	5,871	6,247
Annual % Change		0%	18%	-10%	-3%	6%
Water Sector Emissions (MTCDE)	11,363	11,332	12,594	12,071	12,188	12,655
MTCDE/MG	2.00	2.00	1.88	1.99	2.08	2.03

WASTEWATER: The wastewater sector primarily consists of two wastewater treatment plants—the North Cary Wastewater Reclamation Plant (NCWRF) and the South Cary Wastewater Reclamation Facility (SCWRF). Less than 1% of energy use in the sector is for wastewater lift stations. Electricity is the primary energy source within the sector with the notable exception of the biosolids dryer at the SCWRF that operates on natural gas. The NCWRF uses 48% of the electricity from the sector and 40% of the overall energy. The SCWRF uses 52% of the electricity and 59% of the overall energy. Table 27 lists performance metrics in the sector including two proposed performance indicators: the MTCDE per million gallons (MG) of treated wastewater and the MTCDE from the biosolids dryer per dry ton of biosolids created.

Table 27
Wastewater Sector Emissions

	2005	2006	2007	2008	2009	2010
Wastewater Emissions (MTCDE)	11,188	13,692	13,549	13,726	13,862	14,111
Volume of Wastewater Treated (MG)	4,196	4,309	4,124	3,988	4,071	3,940
MTCDE/MG	2.67	3.18	3.29	3.44	3.40	3.58
Emissions from Biosolids Dryer (MTCDE)	258	1,943	2,001	1,895	1,826	2,025
Biosolids produced (dry tons)	0	3,053	3,044	2,910	2,866	3,108
MTCDE/dry ton		0.64	0.66	0.65	0.64	0.65

Departments in Detail

Activity sector information is helpful, but municipal budgets are crafted around departments rather than sectors. This report includes a complete department-by-department view of energy and emissions in Appendix D. This section serves as an introduction for those reports. Appendix D includes energy report cards for all Town departments as distinguished by the Town budget.

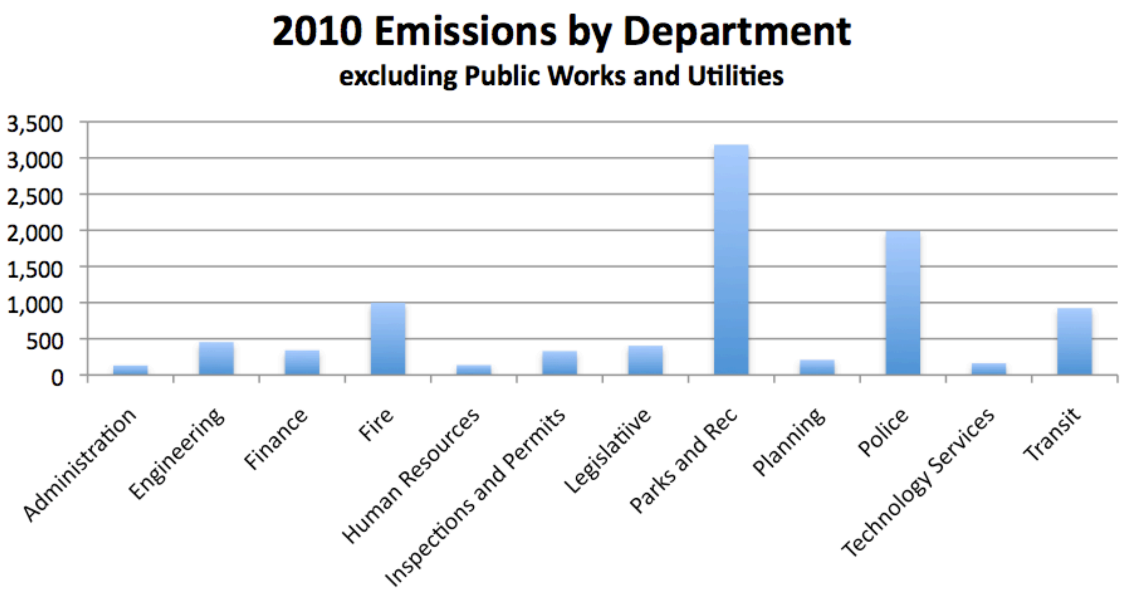


Figure 19: Emissions by Department, 2010

Although the Public Works and Utilities Department is technically a single unit, this report split them based on funding sources. The Public Works department listed in the departmental reports is funded by the general fund while the Utilities Department utilizes the utilities fund revenue stream. Considering over 60% of the Town's emissions result from water and wastewater processes, it is no surprise that the Utilities Department has the largest energy use. Public Works is the next largest energy user since the streetlights and much of the fleet usage falls into that department. Figure 19 omits these two departments due to scale concerns and still shows there are a limited number of departments with significant emissions. These are the departments that have their own facilities. The rest share office space at Town Hall or James Jackson, and some may operate a small number of fleet vehicles. Because there currently are no submeters at town facilities, Town Hall and James Jackson utilities were split using the financial splits used by the Finance department. Exact splits are identified in the departmental reports. Also see Appendix C for a collection of additional tables with departmental data.

5. COMPARISONS WITH OTHER MUNICIPALITIES

Comparing GHG emissions among municipalities is a delicate exercise that deserves a word of warning. Because municipalities are unique in the services offered to residents, it is very difficult to compare municipalities to one another in terms of GHG emissions. Some municipalities have significant transit operations compared to Cary's small operation. Some municipalities rely on counties or other entities for water or wastewater treatment, thus escaping having to report those emissions. As demonstrated earlier when describing the mixing of emissions metrics with some other indicator, a lower result does not clearly imply a "better" emissions performance. Nonetheless, it can be helpful to see how Cary stacks up to other North Carolina municipalities that have completed a GHG inventory.

Table 28
GHG Comparisons with Other North Carolina Municipalities
(From most recent year reported, as denoted in parentheses)

Municipality	Municipal Operations Emissions (MTCDE)	Population (Reporting year)	Emissions per capita (MTCDE/person)	Employees (# of FTE)	Emissions per employee (MTCDE/employee)
Cary (2010)	43,932	143,049	0.307	1,154	38.1
Asheville (2010)	33,053	83,393	0.396	1,149	28.8
Chapel Hill (2010)	15,733	57,233	0.275	702	22.4
Durham (2005)	158,710	241,700	0.657	N/A	N/A
Raleigh (2007)	151,494	392,600	0.386	3,000	50.5
Winston-Salem (2006)	141,500	217,342	0.651	2,500	56.6

As the results in Table 28 are considered, keep in mind the following facts that influence the GHG emissions results presented:

- Asheville operates a large transit agency and three water treatment plants, but Buncombe County provides wastewater treatment (Asheville, 2010).
- Chapel Hill operates one of the largest transit agencies in the state but does not handle any water or wastewater treatment functions.
- Durham City-County municipal operations include an extensive transit agency, water and wastewater treatment, landfill activities, and even the school system (Durham, 2007).
- Raleigh operates a large transit agency, water and wastewater treatment, landfill activities, and a large number of civic buildings (Raleigh, 2008).
- Winston-Salem operates a transit agency, water and wastewater treatment, and landfill activities (Winston-Salem, 2007)

Emissions per capita results show that Cary rivals Chapel Hill for the lowest in the group, but again, the two towns have very different activity profiles. As for emissions per employee, this is a metric that gives especially misleading information. To have a high emissions per employee count could mean that either absolute emissions are high, the Town is understaffed due to budget cuts or high efficiency at staffing, or both.

6. NITROGEN OXIDES (NOx) EMISSIONS INVENTORY

In addition to an energy and GHG inventory, the Town has requested an emissions inventory of nitrogen oxides (NOx), a criteria air pollutant. NOx are a group of highly reactive pollutants that include nitrogen dioxide (NO_2), nitric oxide (NO), nitrous acid (HNO_2), and nitric acid (HNO_3). According to the EPA, this class of gases causes acute respiratory problems even with short-term exposure (EPA, 2009). The EPA also reports that NOx can react with ammonia, moisture, or other compounds to form small particles that can penetrate deeply into the lungs, causing severe respiratory and heart disease.

Sources of NOx emissions include on-road vehicles, non-road equipment, electricity generation, fossil fuel combustion, waste disposal, and industrial processes. In North Carolina in 2005, the EPA estimates 460,415 tons of NOx were emitted with 43% from on-road vehicles, 25% from electricity generation, 17% from non-road equipment, 9% from other fossil fuel combustion, and 3% each from waste disposal and industrial processes. Unlike greenhouse gases, NOx emissions are very difficult to measure accurately because NOx rates can fluctuate with driving speed, vehicle load, ambient temperatures, and other conditions. Even the emissions factors provided by the EPA are estimates of NOx emissions.

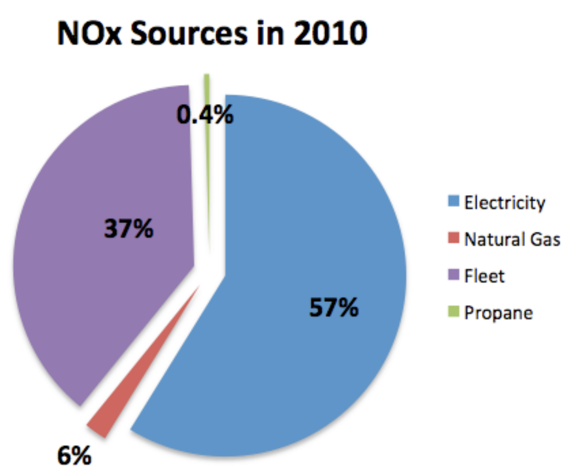


Figure 20: NOx Sources in Cary, 2010

Those NOx sources pertinent to Cary's municipal operations include fleet vehicles, non-road equipment within the town fleet, combustion of natural gas and propane at facilities, and indirectly electricity generation. Waste disposal is typically a very low source, and indirect NOx emissions from waste disposal have not been included because Cary does not operate a landfill. The EPA publishes emissions factors for NOx from electricity generation (through eGRID), propane combustion, and natural gas combustion. The manufacturer of the biosolids dryer at the South Cary Water Reclamation Plant supplied a NOx factor of 0.036 lbs/MMBtu for that equipment. The biosolids dryer utilizes a gas recirculation to

Table 29
NOx Emissions by Source (kg)

By Source	2005	2006	2007	2008	2009	2010
Electricity	42,787	44,731	36,672	36,868	37,587	38,486
Natural Gas	649	1,222	1,124	1,193	1,215	1,328
Fleet	13,204	14,777	17,612	20,482	22,829	25,319
Propane	133	272	302	269	273	306
TOTAL (kg)	56,774	61,001	55,710	58,811	61,904	65,439
Annual Change		7.4%	-8.7%	5.6%	5.3%	5.7%

reduce NOx emissions. Fleet vehicle emission rates were used from an ICLEI emissions tabulation software program called Clean Air Climate Protection (CACP), which provided NOx rates by vehicle type and model year. Non-road equipment was then estimated from the on-road tally using the state ratio of on-road to non-road emissions from 2005.

Figures 20 and 21 demonstrate the NOx sources and trend within Cary. The updated eGRID emission rate for the years 2007 to 2010 was 25% lower than the factor from 2005 and 2006, thus resulting in a decrease from 2006 to 2007.

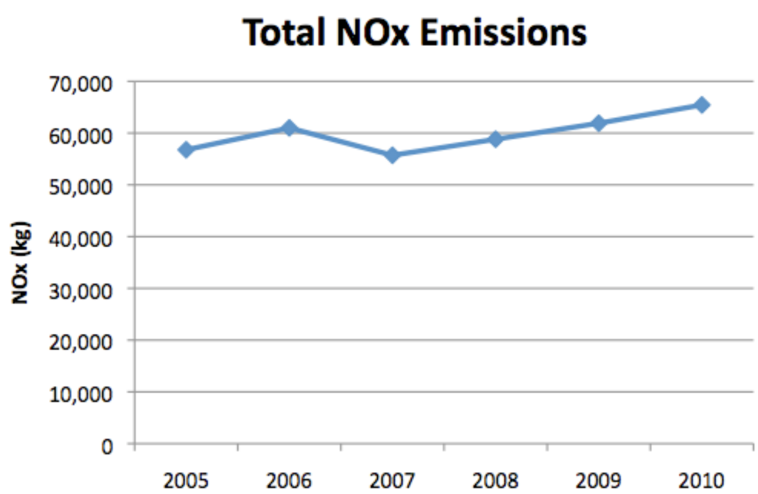


Figure 21: Total NOx Emissions, 2005-2010

7. CONCLUSIONS

Reaction to Results

Energy use has been steadily increasing from every energy source, within every activity sector, and in every department in the Town of Cary's municipal operations. This consistent upward trend in energy consumption, combined with the indication from utility companies that higher energy costs are forthcoming, are all but guarantees that overall energy costs for the Town will continue to rise if efficiencies are not realized. Duke Energy (which is planning to merge with Progress Energy later this year) recently disclosed intentions to raise electricity prices by 6.6% in September 2011. Using this estimate that electricity prices could rise by 6.6%, the Town could see a yearly increase of over $400,000 per year in electricity costs. This amount could be even higher if consumption rates do not stabilize. Creating and implementing a Strategic Energy Plan that identifies and prioritizes savings opportunities may mitigate these expected future cost increases. It is simply too costly for the Town to allow energy use to continue to be an unmanaged expense.

Of particular note, over 60% of the Town's GHG emissions result from the water and wastewater treatment processes. It is understood that this provides a basic need to the entire community, but it also highlights the fact that water is more than just a resource. Conserving water also means conserving energy, so it is quite accurate to view water as a form of energy. Cary already has staff dedicated to promoting and achieving water conservation. This report will hopefully bring more attention to those efforts. If community-wide demand can be lowered, there will be both less water *and* less wastewater requiring energy-intensive treatment.

Concerns Identified

In addition to the concern that vehicle data are outright missing from earlier years, the fleet division provided vehicle mileage data that were unreliable. Some vehicles reported up to 500,000 miles of usage in one year, while others reported negative 250,000 miles. The C-Tran mileage numbers were especially unusable for this report. This greatly hindered a more thorough analysis of the fleet. Departmental average fuel economy contained data that was estimated based on EPA fuel economy estimates and/or limited data from other years.

One known source of emissions that was not included in this report was diesel fuel used to operate the backup electricity generator systems at vital town buildings. No data were available for these sources. It is expected that these emissions would be less than 1% of the municipal total; not including them in this report was not a significant departure for the purposes of this report. It is recommended that Town staff include the gallons of diesel burned per hour in all Town-owned generators to assist in emergency preparedness documents and plans. In the event of a crisis that cuts electricity and limits diesel supply, this could aid in the prioritization and distribution of fuel.

Suggested Actions

With a detailed energy and emissions inventory now complete, the Town of Cary is empowered to make confident energy decisions emboldened by reliable data. Suggestions for actionable items include:

1. ***Begin an energy management program***: With $8.3 million in annual energy expenses, even a 5% decrease in energy costs translates into a substantial savings. A well-run energy management program should save the Town far more than it costs to implement and would provide professional oversight of what currently is an $8.3 million annual expenditure.
    a. *Add submeters/smart meters to large facilities*: The South and North Cary Water Reclamation Plants, the James Jackson complex, the Town Hall complex, and several of the large recreational complexes with sport lighting could benefit from adding smart meters behind the existing meters. As part of a broader energy management plan, smart metering allows energy use in high-use facilities to be managed in real-time to optimize cost savings.
    b. *Utilize software options*: There are many software options available to assist energy and building managers in tracking energy usage. EPA's Energy Star Portfolio Manager is a free database software that includes a weather correcting option. Many private "software as a service" companies offer versions that perform database and reporting actions. Due to the size of the Town, a software system is a logical option to begin storing energy information in a reliable and easily transferable manner.
    c. *Investigate reduction opportunities*: LED streetlights, building efficiency improvements, and more efficient fleet vehicles represent "low hanging fruit" that can possibly result in significant emissions and cost savings.
2. ***Create a strategic energy plan***: Work with the North Carolina State Energy Office and representatives from relevant departments to draft a strategic energy plan that establishes the steps necessary for the Town to save energy costs and move toward energy stability. This inventory and its accompanying Excel data file should be used as a roadmap to determine energy saving opportunities on a department-by-department and even account-by-account basis.
3. ***Implement a fleet efficiency policy to guide new vehicle purchases***: Not only does constant turnover in the vehicle fleet make opportunities available for more energy efficient replacements, but also a vehicle-by-vehicle examination of the fleet has shown that many vehicles are oversized for their uses. By implementing an effective policy that promotes the use of vehicles with high fuel economy, alternative fuels, electric vehicles, and hybrid vehicles, fleet emissions should stabilize and soon begin decreasing.
4. ***Promote energy literacy throughout the Town***: Promoting energy literacy means instructing staff on how municipal energy is consumed, billed, and saved and including energy use updates in senior management meetings and general departmental staff meetings. After appointing an energy manager, enlist that person to act as an energy liaison to the Town's departments.

REFERENCES

American Council for an Energy-Efficient Economy. Target Heating System Efficiency Requirements. 2011. [Retrieved from http://www.aceee.org/consumer/heating on 2011 February 18].

Birdsey RA. Carbon storage for major forest types and regions in the conterminous United States. 1996. In: Sampson, R.L., Hair, D. (Eds.), Forest and Global Change, Vol. 2: Forest Management Opportunities for Mitigating Carbon Emissions. American Forests, Washington, DC: 1996. pp. 1–26.

City of Asheville. *Carbon Footprint Annual Report*. FYI 2009-2010. Print.

City of Durham and Durham County. *Greenhouse Gas and Criteria Air Pollutant Emissions Inventory and Local Action Plan for Emissions Reductions.* ICLEI Energy Services. 2007 Sept 12. Print.

City of Raleigh. *Greenhouse Gas Inventory: Municipal Operations*. ICF International. 2010 July 12. Print.

City of Winston-Salem. *Greenhouse Gas Inventory and Local Action Plan to Reduce Emissions*. Aug 2008. Print.

ICLEI Local Governments for Sustainability. *Local Government Operations Protocol: For the quantification and reporting of greenhouse gas emissions inventories.* v.1.1. May 2010. Print.

National Energy Technology Laboratory (NETL). *Reducing CO_2 Emissions by Improving the Efficiency of the Existing Coal-fired Power Plant Fleet.* U.S. Dept of Energy/ National Energy Technology Laboratory. 2008 July 23. Print.

National Oceanic and Atmospheric Administration. "Comparative Climatic Data." National Climatic Data Center. 2001.

North Carolina Office of State Budget and Management (OSBM). *Multicounty Municipalities: July 2009 Land Area Distribution, Sq. Miles.* State of North Carolina. 2009 Sept 20. [Retrieved from http://www.osbm.state.nc.us/ncosbm/facts_and_figures/socioeconomic_data/population_estimates/demog/partpa09.htm on 2011 January 24].

U.S. Department of Energy (DOE). "Energy Efficiency and Conservation Block Grant Program." *Weatherization & Intergovernmental Program*. [Retrieved from http://www1.eere.energy.gov/wip/eecbg.html on 2011 March 12.]

U.S. Energy Information Administration. "Table 5A. Residential Average Monthly Bill by Census Division, and State, 2009." *Frequently Asked Questions*. U.S. Dept of Energy. [Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3 on 2011 March 12].

U.S. Energy Information Administration. *International Energy Annual 2006.* U.S. Dept. of Energy. 2008. [Retrieved from http://www.eia.gov/emeu/iea/contents.html on 2010 April 10].

U.S. Environmental Protection Agency. *Advanced Technologies & Energy Efficiency.* U.S. Environmental Protection Agency. 2011 February. [Retrieved from http://www.fueleconomy.gov/feg/atv.shtml on 2011 February 15]

U.S. Environmental Protection Agency. *Air Emissions Sources: Nitrogen Oxides.* U.S. Environmental Protection Agency. 2009 Nov 4. [Retrieved from http://www.epa.gov/air/emissions/nox.htm on 2011 February 22].

U.S. Environmental Protection Agency. *eGRIED2010 v. 1.0: Year 2007 Summary Tables.* U.S. Environmental Protection Agency. 2007. [Retrieved from http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_0_year07_SummaryTables.pdf on 2011 March 18].

U.S. Environmental Protection Agency. *Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle (EPA420-F-05-004).* U.S. Environmental Protection Agency. 2005 Feb 4. [Retrieved from http://www.epa.gov/otaq/climate/420f05004.htm#recommendation on 2010 November 24].

U.S. Environmental Protection Agency. *Energy Star Performance Ratings: Methodology for Incorporating Source Energy Use.* U.S. Environmental Protection Agency. 2011 March. [Retrieved from http://www.energystar.gov/ia/business/evaluate_performance/site_source.pdf on 2011 March 15].

Appendix A: Fossil Fuels, Climate Science, and GHG Reduction Targets

Fossil Fuel Use

Especially since the Industrial Revolution, human activity has been consuming ever-increasing quantities of fossil fuels. According to the U.S. Energy Information Administration (EIA), fossil fuels, which include coal, natural gas, and petroleum, were the source of over 86% of the world's energy consumption in 2006[1]. These fuels provide the majority of our energy used to produce electricity, operate our motor vehicles, and heat our buildings. Fossil fuels are the dominant energy source because they are found in large quantities throughout the world, contain a substantial amount of energy, and are relatively easy to extract. This abundant supply of cheap energy has fueled centuries of exceptional economic growth throughout the world and in the United States.

However, we are beginning to realize that there are environmental costs to our energy choices. Fossil fuels are potent energy sources because they possess energy in the form of chemical bonds. In order to release that energy, combustion must take place—the fuel must be burned. That reaction releases energy and a byproduct: gaseous carbon dioxide. Because fossil fuels have essentially been storing energy and carbon for millions of years below the earth's surface, the carbon within fossil fuels has been withheld from the naturally occurring carbon cycle (Figure 22). The earth's ecosystem had reached a carbon equilibrium that helped shape and support our current climate and biodiversity. But as human activity continues to transfer carbon dioxide from fossil fuels to the atmosphere, the natural cycle becomes disrupted and excess atmospheric carbon dioxide builds. These rising concentrations of carbon dioxide threaten our climate.

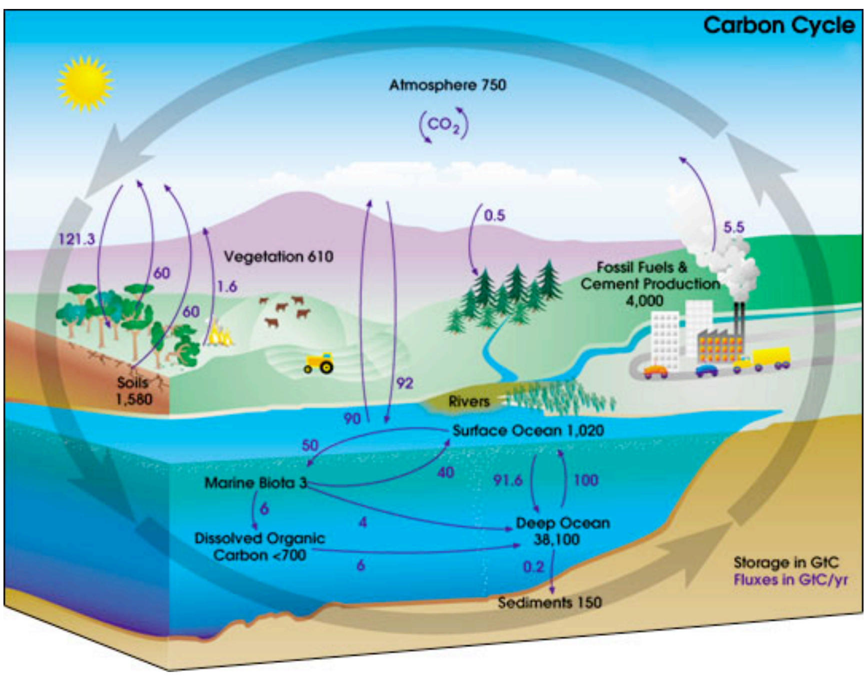


Figure 22: The Carbon Cycle. (Image from NASA Earth Science Enterprise.)
http://earthobservatory.nasa.gov/Features/CarbonCycle/carbon_cycle4.php

[1] Energy Information Administration (2006), *International Energy Annual 2006*

Greenhouse Gases and Climate Change

Carbon dioxide, water vapor, nitrous oxide, methane, and ozone are naturally occurring greenhouse gases. Radiation from the sun heats the earth, and these natural greenhouse gases trap some of that heat, like a blanket, through the greenhouse effect. The greenhouse effect is important in regulating the earth's temperature; without it, the earth would experience a colder climate and likely larger temperature differences during 24-hour periods. However, as concentrations of greenhouse gases increase from human activities such as combustion of fossil fuels, the greenhouse effect becomes stronger and causes the average global temperature to rise (the blanket becomes thicker). The atmospheric carbon dioxide concentration is considered the leading indicator for measuring the greenhouse effect. (Although water vapor is the most prevalent greenhouse gas, it does not force the greenhouse effect but rather acts as a positive feedback because atmospheric water vapor concentrations are dependent upon temperature.) The Vostok ice cores from Antarctica have shown a correlation between carbon dioxide and global temperature, as seen in Figure 23. Throughout the past 600,000+ years, the atmospheric carbon dioxide concentration has fluctuated (but never exceeded 300 ppm) and carbon dioxide corresponded with temperature fluctuations. Additional ice cores from the Law Dome in Antarctica show that from 1006 CE until the Industrial Revolution, carbon dioxide concentrations were stable between 275 and 284 ppm.[2] Since 1959, the National Oceanic and Atmospheric Administration (NOAA) has recorded the atmospheric carbon dioxide concentration. That average annual concentration has risen every year since 1959 and was at an alarming 389.8 ppm in 2010. Over the past decade, NOAA data show the average carbon dioxide concentration has been rising by roughly 2 ppm per year.

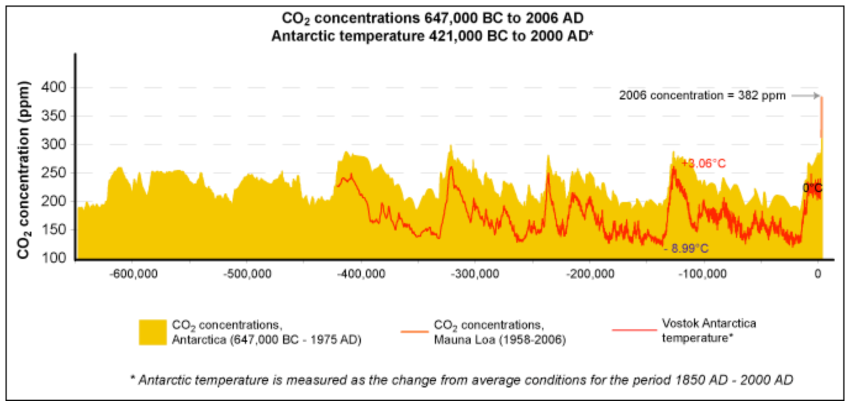


Figure 23: CO_2 concentrations and temperature. (Image from the EPA.) http://www.epa.gov/climatechange/science/pastcc_fig1.html

Although the burning of fossil fuels is the primary source of anthropogenic greenhouse gas emissions, there are many other sources of direct emissions from human activities including cement production (which involves chemical reactions that emit carbon dioxide), solid waste accumulation (which causes methane production), and agricultural activities, such as livestock that emit methane and fertilizers that emit nitrous oxide. There are also

---

[2] D.M. Etheridge, et al. (1998). *Historical CO_2 records from the Law Dome DE08, DE08-2, and DSS ice cores*. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy.

trace emissions of synthetic chemicals and refrigerants such as hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) that increase the greenhouse effect. According to the Carbon Dioxide Information Analysis Center at the Department of Energy, methane and nitrous oxide concentrations have been increasing since the Industrial Revolution but at a slower rate than carbon dioxide and are still at concentrations 200 and 1200 times lower than carbon dioxide, respectively.[3]

The U.S. Environmental Protection Agency (EPA) reports that scientific evidence has determined with virtual certainty that:

- Human activities are changing the composition of Earth's atmosphere.
- The atmospheric buildup of greenhouse gases is largely the result of human activities such as the burning of fossil fuels.
- An "unequivocal" warming trend of about 0.56 to 0.92°C occurred from 1906-2005.
- The major greenhouse gases emitted by human activities remain in the atmosphere for periods ranging from decades to centuries. It is therefore virtually certain that atmospheric concentrations of greenhouse gases will continue to rise over the next few decades.
- Increasing greenhouse gas concentrations tend to warm the planet.[4]

The existence of global warming and beginning of climate change is fully supported by climate science. The only debate within the scientific community surrounds the predictions of how much and how fast the global temperature will rise. With rising global temperatures and rising carbon dioxide concentrations, a wide range of climate impacts are expected by the Intergovernmental Panel on Climate Change (IPCC), including the following:

- Changes in average regional precipitation with some regions experiencing an increase, others a decrease
- An increase in the intensity of precipitation events that will lead to more floods
- More intense but less frequent tropical cyclones
- Sea-level rise and ocean acidification

An extreme loss of biodiversity, increased human health concerns, and significant disruptions in food chains are likely to occur if climate change continues unabated.

Although no official global targets have been set, it is widely accepted that in order to avert dangerous levels of climate change, the earth's average temperature must not rise more than 2°C above pre-industrial levels. It has already risen about 0.74°C. Dr. James Hansen, head of the Goddard Institute of Space Science at NASA and a leading climate scientist, has joined other scientists to calculate 350 ppm as the safe upper limit for carbon dioxide concentrations.[5] To reiterate, carbon dioxide was at 389 ppm in 2010.

---

[3] Carbon Dioxide Information Analysis Center(2009) *Recent Greenhouse Gas Concentrations*
[4] U.S. Environmental Protection Agency (2009), *Climate Change Science: State of Knowledge*
5 Hansen et al (2008). *Target atmospheric CO2: Where should humanity aim?* Open Atmospheric Science Journal, Volume 2, p. 217-231

Reduction Targets and Local Commitments

In 2007, the IPCC established that in order to achieve a stabilization of atmospheric carbon dioxide equivalent of around 450 ppm (this includes carbon dioxide and the other anthropogenic greenhouse gases), developed countries would have to reduce total greenhouse gas emissions 80% to 95% below 1990 levels by 2050.[6] President Barack Obama and his administration had been calling for reductions throughout the U.S. of 17% below 2005 levels by 2020 and 83% by 2050.

Cary expressed a commitment to environmental sustainability by becoming a member of ICLEI-Local Governments for Sustainability in 2008. ICLEI is a membership association of local governments dedicated to climate protection and sustainable development by providing climate protection analysis tools and assistance to local governments. ICLEI has taken the lead in organizing communities to reduce greenhouse gas emissions and has established "Five Milestones" that provide a simple, standardized approach to reaching the goal of climate mitigation. The first step, achieved by this document, is to conduct a detailed greenhouse gas emissions inventory for a selected baseline year and a forecast of emissions to a target year.

Figure 24: The Five Milestones to achieving climate mitigation

Many other cities in North Carolina have conducted GHG emissions inventories and have gone another step to make pledges to reduce the greenhouse gas emissions from their municipal operations. Those commitments include the following cities and targets:

- Asheville, an 80% absolute reduction from 2007 levels by 2050
- Chapel Hill, a 60% reduction per capita from 2005 levels by 2050
- Durham, a 50% absolute reduction from 2005 by 2030
- Winston-Salem, a stabilization of emissions by 2010.

On the national scale, President Obama announced in January 2010 that the federal government would set an example for the nation and reduce the greenhouse gas emissions from federal operations 28% below 2008 levels by 2020.[7]

---

[6] IPCC (2007). *Climate Change 2007: Mitigation of Climate Change*. Working Group III Contribution to the IPCC Assessment Report 4. Chapter 13, p. 776.

[7] Office of the Press Secretary (2010). *President Obama Sets Greenhouse Gas Emissions Reduction Target for Federal Operations*. January 29, 2010.

Appendix B: Additional GHG Accounting Details

Establishing Organizational Boundaries

The first accounting structure for reporting municipal operation emissions is to define the organizational boundary: what departments, services, and organizational structures are considered part of "municipal operations?" The ICLEI protocol allows for organizational boundaries to be established based on operational control or financial control. The state of California requires municipalities to report according to operational control, and ICLEI suggests using operational control to prevent some instances of double counting that can occur when using financial control boundaries. To follow the conventional approach and to prevent possible double counting of emissions when regional counts are assembled between multiple organizations, the inventory for the Town of Cary has been conducted using an operational control boundary where operational control is defined as:

> *1) Wholly owning an operation, facility, or source; or*
>
> *2) Having the full authority to introduce and implement operational and health, safety and environmental policies (including both GHG- and non-GHG-related policies).*[8]

Many functions clearly fall under the Town's operational control since the Town fully owns numerous facilities and can set operational policies in other instances. Emergency services (police and fire rescue), parks and recreational facilities and services, and administrative services (finance, planning, engineering, etc.) are among those activities that are clearly under the Town's operational control. All fleet vehicles owned and operated by the Town are within the organizational boundary, including the vehicles used by the transit organization, C-Tran. Because the Town has written a detailed contract that actually exerts operational decisions over the operators of C-Tran (bus size, fuel type, routing, etc.), the Town must associate the emissions from C-Tran within its operational boundaries.

There are at least 168 traffic signals across Cary, most of which are owned by the North Carolina Department of Transportation (NCDOT) with only 16 owned by the Town. Those signals owned by the Town are within its operational control. The NCDOT signals, although they serve Cary and are partially managed by the Town's traffic engineers, are considered under NCDOT's operational control. The Town pays the operational costs for, performs maintenance on, and sets all signalization patterns for town-owned signals. In contrast, NDCOT pays the operational costs for the NCDOT-owned signals and reimburses Cary for all maintenance and other services performed on those signals. In these instances, however, NCDOT ultimately has the authority to control where their signals are placed and how they are signalized. NCDOT traffic signals fall outside of the Town's operational control.

Streetlights are another special case. In Cary and many other municipalities served by Progress Energy, the utility owns the streetlights while the municipality leases them. This arrangement is addressed in the ICLEI protocol as "Emissions from Leased Assets." Even

[8] ICLEI (2010), *Local Government Operations Protocol*, Version 1.1, page 14

though another entity owns the equipment, the lessee (in this case, the Town) is responsible for the emissions because the lessee has operational control over the leased equipment. State-owned roads are required to be lit by the municipality according to state guidelines while streetlight placement on town-owned roads is guided by policy developed by the town. Because Cary is leasing the property yet still has operational control over the emission source, all streetlights paid for by the Town are considered under the Town's operational control despite being owned by Progress Energy.

The streetlight arrangement is very similar to joint-use and partnered spaces, such as the Middle Creek Community Center, USA Baseball Training Complex, and WakeMed Soccer Park. Although the Town entered into a construction agreement with another organization and may not own the office space itself, these emission sources are under the Town's operational control because it controls the operations and energy use. The converse is also true when the Town is the lessor, as in the case of the Koka Booth Amphitheatre at Regency Parkway. Since the Koka Booth Amphitheatre controls the facility, they are responsible for the emissions. If reporting these emissions at all, the Town could report these as indirect emissions (see *Operational Boundaries* section), since as a landlord the Town does have indirect responsibility for the efficiency of the facility.

Operational Boundaries

Once the organizational boundary has been established, operational boundaries are determined to organize the emissions into one of three standard classifications called emission scopes. The three scopes of greenhouse gas emissions are as follows:

> *Scope 1: All direct greenhouse gas emissions that are emitted on site.*
>
> *Scope 2: Indirect greenhouse gas emissions associated with the consumption of purchased or acquired energy in the form of electricity, steam, heating, or cooling.*
>
> *Scope 3: All other indirect emissions not covered in Scope 2, such as emissions resulting from the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the town (e.g. employee commuting and business travel), outsourced activities, waste disposal, etc.*[9]

Scope 1 and 2 emissions are considered the "total emissions" of the reporting entity. Scope 1 emissions are essentially tailpipe emissions that are generated on site as a direct result of operations that are within the organizational boundary of the reporting entity. Scope 2 emissions are those that result from purchased energy but are emitted off site, typically at a facility operated by a utility provider to generate electricity, steam, or chilled water. In the case of the Town of Cary, Scope 2 emissions comprise just purchased electricity. Even though another entity (Progress Energy, Duke Energy, or those who supply the Town of Apex) is directly producing the emissions reported as Scope 2, those emissions are a direct consequence of the energy use of town operations. The town controls the thermostat, so to speak, and can regulate their electricity consumption even though they cannot necessarily control the type of materials used to generate that electricity.

[9] ICLEI Local Government Operations Protocol, Version 1.1, page 22

Scope 3 emissions are from activities that generally fall outside of the reporting entity's organizational boundary yet are still indirectly related to the entity's operational decisions. Scope 3 emissions are optional to report as they are, by nature, another entity's Scope 1 or Scope 2 emissions. Solid waste landfill disposal, contracted services, employee travel, and employee commuting are perhaps the most significant Scope 3 emissions for Cary. As an example as to why these are Scope 3, an employee commuting to work is the one responsible for the direct Scope 1 tailpipe emissions from their personal vehicle. If all businesses and individuals inventoried their greenhouse gas emissions, that employee would report their commuting emissions as part of their personal Scope 1 emissions, while their employer should account for those emissions as indirect Scope 3 emissions. That employee could decide to reduce their personal, direct emissions by riding a bicycle to work or carpooling, but since the employer does not have direct control over that decision, they are not held fully responsible for those emissions. The employer is, however, indirectly responsible for those emissions because they hired the employee, they chose the location of the workplace, and they more than likely subsidize driving alone to work by providing free parking.

From the perspective of the reporting entity, Scope 3 emissions are usually more difficult to count and more difficult to directly control. An extensive count of Scope 3 emissions can still be valuable information for a reporting entity, and in the case of a local government, reducing Scope 3 emissions should result in a reduction of the community-wide emissions.

Scoping assignments are standard practice in greenhouse gas accounting. As the ICLEI protocol mentions, reporting both Scope 1 and Scope 2 emissions as total emissions for a local government yields an emissions profile that accurately reflects the activities and energy decisions of that government's operations.

List of Town Activities by Scope

Among the activities under the Town of Cary's operational control, the following activities are classified as Scope 1 emissions:

- Town vehicle fleet
- C-Tran vehicle fleet
- Natural gas combustion in town buildings from gas purchased from PSNC Energy
- Fugitive N_2O from the wastewater treatment processes
- Fugitive HFC refrigerants from the town vehicle fleet
- Fugitive HFC refrigerants from the transit vehicle fleet
- Fugitive HFC refrigerants from facilities' HVAC systems

Among the activities under the Town of Cary's operational control, the following activities are classified as Scope 2 emissions:

- Electricity use in all physical facilities from Progress Energy, Duke Energy and Town of Apex Energy including those from public works, transit, town hall, parks and recreation, emergency services, water treatment, and wastewater treatment
- Electricity use in Town-owned traffic signals
- Electricity use in streetlights paid for by the Town of Cary

Appendix C: Additional Data Tables

Table 30
Emissions (MTCDE)

By Department	2005	2006	2007	2008	2009	2010
Administration	68	127	114	122	124	131
Engineering	270	417	370	426	437	454
Finance	234	311	309	317	324	341
Fire	765	798	869	913	918	999
Human Resources	79	133	123	129	132	136
Inspections and Permits	168	262	245	328	312	329
Legislatiive	222	386	322	364	385	403
Parks and Rec	2,772	2,714	2,780	2,915	2,996	3,182
Planning	126	198	169	193	201	208
Police	1,158	1,258	1,397	1,762	1,798	1,990
Public Works	5,332	5,755	6,171	6,834	7,349	7,629
Technology Services	146	146	147	158	159	161
Transit	349	599	630	659	801	923
Utilities	22,664	25,185	26,333	26,042	26,308	27,043
TOTAL	34,353	38,291	39,978	41,161	42,244	43,932

Table 31
On-Site Energy Use (MMBtu)

By Department	2005	2006	2007	2008	2009	2010
Administration	559	1,137	1,042	1,096	1,101	1,172
Engineering	2,869	4,204	3,619	4,353	4,536	4,697
Finance	2,143	3,015	3,133	3,197	3,246	3,460
Fire	8,911	9,438	9,990	10,604	10,691	11,841
Human Resources	636	1,172	1,099	1,135	1,149	1,203
Inspections and Permits	1,830	2,726	2,537	3,683	3,455	3,661
Legislatiive	2,037	3,501	2,729	3,228	3,525	3,687
Parks and Rec	21,147	20,575	20,831	22,096	22,895	24,545
Planning	1,279	1,904	1,538	1,838	1,966	2,017
Police	12,034	13,192	15,156	20,154	20,526	23,152
Public Works	47,493	52,982	59,884	67,797	73,911	78,500
Technology Services	1,304	1,256	1,268	1,393	1,375	1,395
Transit	5,526	9,703	10,161	10,568	12,836	14,411
Utilities	150,783	188,185	198,997	196,106	197,046	204,705
TOTAL MMBtu	**258,550**	**312,991**	**331,984**	**347,248**	**358,258**	**378,446**

Table 32
Electricity Use (kWh)

By Department	2005	2006	2007	2008	2009	2010
Administration	112,800	198,160	179,320	195,000	200,240	209,520
Engineering	296,100	520,170	470,715	511,875	525,630	549,990
Finance	310,520	390,000	360,480	371,240	383,760	395,880
Fire	766,493	756,924	898,270	922,856	935,155	978,873
Human Resources	134,640	210,370	195,840	207,610	214,770	219,180
Inspections and Permits	169,200	297,240	268,980	292,500	300,360	314,280
Legislatiive	338,400	594,480	537,960	585,000	600,720	628,560
Parks and Rec	4,888,670	4,801,930	5,066,850	5,272,697	5,389,155	5,687,424
Planning	155,100	272,470	246,565	268,125	275,330	288,090
Police	1,292,901	1,338,614	1,375,565	1,449,704	1,470,440	1,496,210
Public Works	7,635,736	7,902,074	8,083,848	8,452,598	8,885,452	8,952,363
Technology Services	226,912	235,012	241,732	254,992	258,592	263,512
Transit	0	0	0	0	0	0
Utilities	42,433,565	43,912,740	46,639,368	46,124,742	46,735,598	47,775,129
TOTAL	58,761,037	61,430,184	64,565,493	64,908,939	66,175,202	67,759,011

Table 33
Natural Gas Use (therms)

By Department	2005	2006	2007	2008	2009	2010
Administration	1,741	4,608	4,297	4,306	4,180	4,566
Engineering	8,962	14,145	7,859	11,615	14,376	14,941
Finance	1,741	4,608	4,297	4,306	4,180	4,566
Fire	21,456	18,539	19,381	21,349	22,569	25,864
Human Resources	1,567	4,147	3,867	3,876	3,762	4,110
Inspections and Permits	4,780	7,544	4,191	6,194	7,667	7,969
Legislatiive	8,820	14,727	8,935	12,319	14,750	15,426
Parks and Rec	42,728	39,137	31,746	37,082	40,858	47,317
Planning	4,182	6,601	3,667	5,420	6,709	6,973
Police	28,125	24,040	23,722	28,212	26,402	26,198
Public Works	1,980	1,201	1,434	848	244	444
Technology Services	4,963	4,242	4,186	4,979	4,659	4,623
Transit	0	0	0	0	0	0
Utilities	48,583	365,208	376,237	356,240	343,305	380,671
TOTAL	179,629	508,747	493,821	496,746	493,660	543,667

Table 34
Propane Use (gals)

By Department	2005	2006	2007	2008	2009	2010
Administration						
Engineering						
Finance	1,139	2,324	2,576	2,291	2,330	2,607
Fire						
Human Resources	214	436	483	430	437	489
Inspections and Permits						
Legislatiive						
Parks and Rec	102	208	230	205	208	233
Planning						
Police						
Public Works	8,388	17,119	18,976	16,876	17,163	19,200
Technology Services						
Transit						
Utilities	427	872	966	859	874	977
TOTAL	10,269	20,958	23,231	20,661	21,012	23,506

Table 35
Gasoline Use (gals)

By Department	2005	2006	2007	2008	2009	2010
Administration						
Engineering	7,699	8,116	9,819	11,558	10,437	10,608
Finance	6,449	8,094	9,910	10,327	10,452	11,320
Fire	3,319	4,743	5,465	6,054	4,391	4,876
Human Resources						
Inspections and Permits	6,198	7,657	9,603	16,523	13,303	14,338
Legislatiive						
Parks and Rec	1,470	2,062	2,773	3,024	3,211	3,088
Planning	2,651	2,513	2,638	3,050	2,845	2,695
Police	37,240	48,074	63,067	97,837	102,800	123,241
Public Works	65,839	72,250	76,989	95,300	97,429	95,566
Technology Services	268	243	199	204	216	270
Transit	12,941	11,863	14,750	18,151	22,386	43,511
Utilities	5,787	9,260	11,894	15,753	16,678	17,454
TOTAL	149,861	174,876	207,106	277,780	284,148	326,965

Table 36
B20 Biodiesel Use (gals)

By Department	2005	2006	2007	2008	2009	2010
Administration						
Engineering						
Finance						
Fire	27,449	32,400	31,629	33,535	34,500	38,983
Human Resources						
Inspections and Permits						
Legislatiive						
Parks and Rec						
Planning						
Police	1,139	1,553	1,517	1,147	135	157
Public Works	90,004	112,505	152,904	186,825	219,198	251,449
Technology Services						
Transit	28,721	60,410	61,126	60,987	73,768	65,933
Utilities	2,741	4,343	4,838	7,724	7,958	9,934
TOTAL	150,053	211,212	252,013	290,219	335,559	366,456

Table 37
Estimated Energy Cost

By Department	2010
Administration	$20,661
Engineering	$75,895
Finance	$63,352
Fire	$187,444
Human Resources	$22,449
Inspections and Permits	$57,823
Legislatiive	$63,352
Parks and Rec	$617,288
Planning	$33,808
Police	$366,498
Public Works	$2,643,435
Technology Services	$25,663
Transit	$197,944
Utilities	$3,936,989
TOTAL	$8,312,599

Table 38
Vehicle and Equipment Count

By Department	2005	2006	2007	2008	2009	2010
Administration						
Engineering	18	19	25	25	25	25
Finance	9	12	14	13	18	18
Fire	33	35	40	43	46	48
Human Resources						
Inspections and Permits	13	13	26	26	26	33
Legislatiive						
Parks and Rec	4	5	4	7	7	7
Planning	5	5	5	5	5	7
Police	52	59	89	108	116	136
Public Works	159	196	216	265	291	306
Technology Services	1	1	1	1	2	2
Transit	20	29	27	28	36	59
Utilities	19	23	24	33	37	40
TOTAL	333	397	471	554	609	681

Table 39
Vehicle and Equipment Count

By Division	Department	2005	2006	2007	2008	2009	2010
Purchasing	Finance	2	2	2	1	2	3
Customer Accounting	Finance	7	10	12	12	16	15
Technology Services	Tech Services	1	1	1	1	2	2
Police	Police	52	59	89	108	116	136
Fire	Fire	33	35	40	43	46	48
Engineering	Engineering	18	19	25	25	25	25
Planning	Planning	5	5	5	5	5	7
Inspections & Permits	Inspections	13	13	26	26	26	33
Fleet	Public Works	12	12	12	12	12	9
Transit	Transit	20	29	27	28	36	59
Parks & Rec Admin	Parks and Rec	1	1		2	2	2
Recreation Programs	Parks and Rec	1	2	2	3	3	3
Athletics	Parks and Rec	2	2	2	2	2	2
Public Works/Utilities Admin	Public Works	3	3	3	3	3	4
Water Conservation	Utilities	1	1	1	1	1	1
Pretreatment	Utilities	1	2	2	3	3	3
Buildings and Grounds	Public Works	50	60	66	79	89	100
Field Operations	Public Works	78	93	101	135	141	146
Solid Waste	Public Works	13	22	24	26	32	34
Recycling	Public Works	3	6	10	10	14	13
Utility Systems Maintenance	Utilities	6	10	10	15	15	16
N Cary Water Reclamation	Utilities	3	3	4	5	6	6
S Cary Water Reclamation	Utilities	4	4	4	4	6	7
Water Treament Plant	Utilities	4	3	3	5	6	7
TOTAL		333	397	471	554	609	681

Appendix D: Departmental Energy Reports for 2010

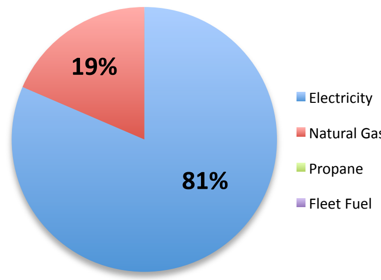
Administrative

Total Emissions (MTCDE):	131
Change from 2009:	+5.5%
Percent of Town Total:	0.3%
Estimated Energy Cost:	$20,661
Activities with Energy Use:	Town Hall
Number of Fleet Vehicles:	0
Average MPG:	-
Shared Buildings:	Town Hall A-- 30%

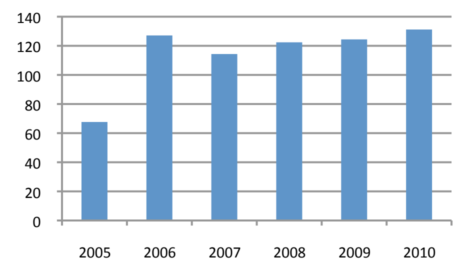
The only energy consumption by the Administrative Department is from the office space in Town Hall A.

Due to the shared space, reduction opportunities are limited to efficiency improvements and energy reduction strategies at Town Hall.

Emissions Profile



Emissions Trend

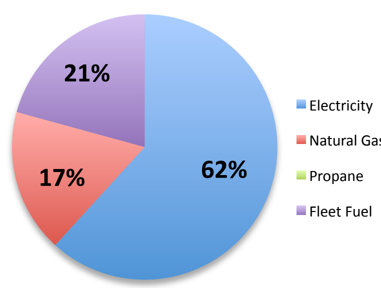


Engineering

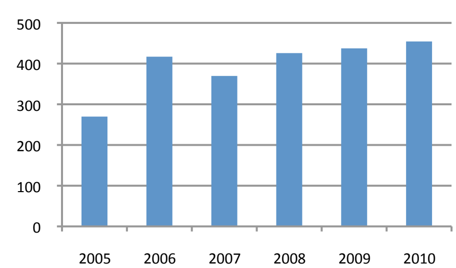
Total Emissions (MTCDE):	454
Change from 2009:	+3.9%
Percent of Town Total:	1.0%
Estimated Energy Cost:	$75,895
Activities with Energy Use:	Town Hall Fleet Vehicles
Number of Fleet Vehicles:	25
Average MPG:	14.0
Shared Buildings:	Town Hall B-- 30%

Among the most utilized vehicles in the 2010 Engineering Department fleet were a Chevrolet Suburban and Ford Excursion, each 10+ years old. Opportunities to downsize the fleet would save emissions. If full-sized SUVs are essential to daily activities, the hybrid Ford Escape offers a fuel efficiency rating more than 3 times higher than the 9.5 MPG recorded in 2010 by the Excursion.

Emissions Profile



Emissions Trend

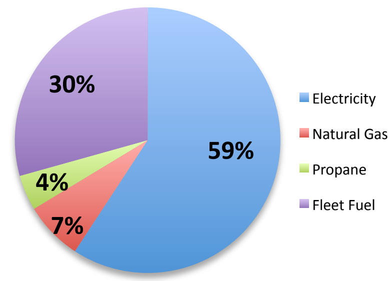


Finance

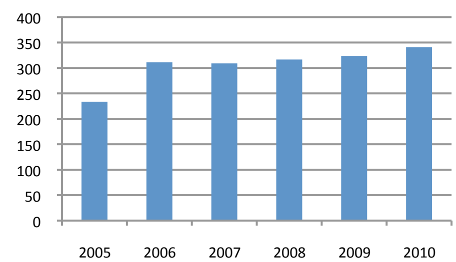
Total Emissions (MTCDE):	341
Change from 2009:	+5.4%
Percent of Town Total:	0.8%
Estimated Energy Cost:	$63,352
Activities with Energy Use:	Town Hall James Jackson Fleet Vehicles
Number of Fleet Vehicles:	18
Average MPG:	13.3
Shared Buildings:	Town Hall A-- 30% James Jackson 420-- 40%

Energy use in office space generates the most emissions in the Finance Department, and gains in efficiency at the buildings would reduce totals. The 18-vehicle fleet consists entirely of midsized pickups that receive less than 15 miles per gallon, yielding opportunity for more efficient replacements.

Emissions Profile



Emissions Trend

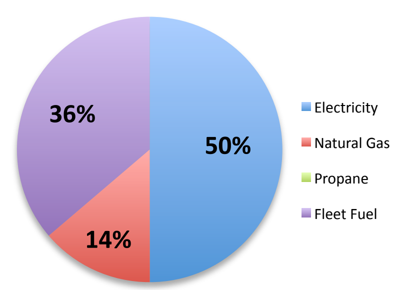


Fire

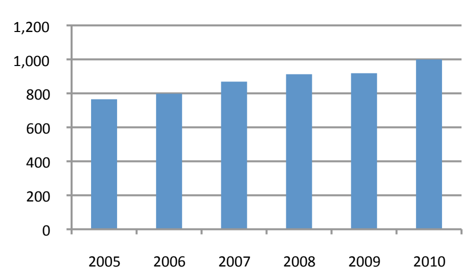
Total Emissions (MTCDE):	999
Change from 2009:	+8.8%
Percent of Town Total:	2.3%
Estimated Energy Cost:	$187,444
Activities with Energy Use:	Fire Stations Fleet Vehicles
Number of Fleet Vehicles:	48
Average MPG:	6.3

Building Performances	MTCDE	MTCDE/1000sf
Fire Station #7	115.9	6.8
Fire Station #1	94.3	7.9
Fire Station #5	83.4	8.8
Fire Station #4	81.1	11.3
Fire Station #6	80.0	7.0
Fire Station #3	76.3	10.6
Fire Station #2	51.6	12.3
Fire Admin	42.2	5.1

Emissions Profile



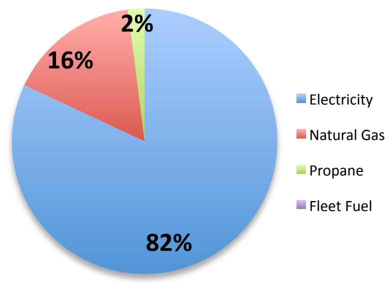
Emissions Trend



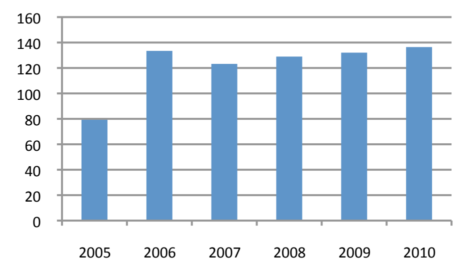
Human Resources

Total Emissions (MTCDE):	136
Change from 2009:	+3.3%
Percent of Town Total:	0.3%
Estimated Energy Cost:	$22,449
Activities with Energy Use:	Town Hall James Jackson
Number of Fleet Vehicles:	0
Average MPG:	-
Shared Buildings:	Town Hall A--27% James Jackson 400-- 5%

Emissions Profile



Emissions Trend



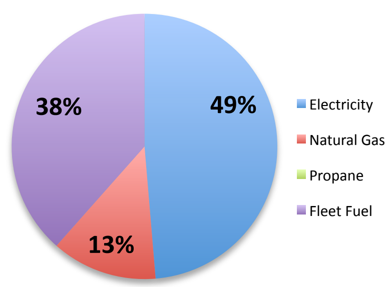
The only energy consumption by the Human Resources Department is from the office space in Town Hall A and James Jackson.

Due to the shared space, reduction opportunities are limited to efficiency improvements at Town Hall and James Jackson.

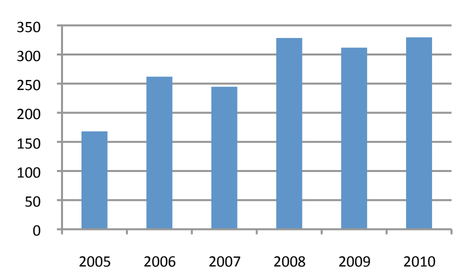
Inspections and Permits

Total Emissions (MTCDE):	329
Change from 2009:	+5.7%
Percent of Town Total:	0.7%
Estimated Energy Cost:	$57,823
Activities with Energy Use:	Town Hall Fleet Vehicles
Number of Fleet Vehicles:	33
Average MPG:	15.1
Shared Buildings:	Town Hall B-- 16%

Emissions Profile



Emissions Trend

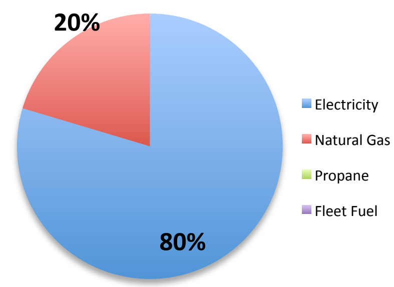


With emissions split between energy use in space at Town Hall and an expanding vehicle fleet, the Inspections and Permits Department can reduce their emissions most easily by right-sizing the 33 vehicle fleet it operates. Purchases in 2010 of the Toyota Prius and Ford Escape hybrids are a step in the right direction and should be repeated in future vehicle replacements.

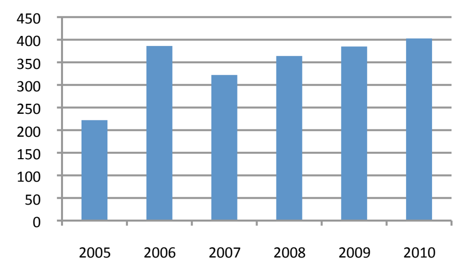
Legislative

Total Emissions (MTCDE):	403
Change from 2009:	+4.6%
Percent of Town Total:	0.9%
Estimated Energy Cost:	$63,352
Activities with Energy Use:	Town Hall
Number of Fleet Vehicles:	0
Average MPG:	-
Shared Buildings:	Town Hall A-- 13% Town Hall B-- 27%

Emissions Profile



Emissions Trend



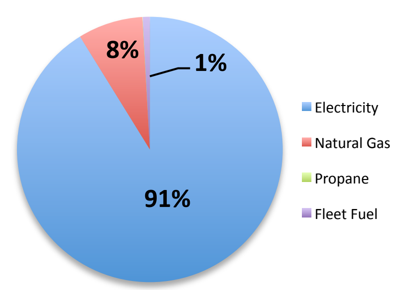
The only energy consumption by the Legislative Department is from the office space in Town Hall A and B.

Due to the shared space, reduction opportunities are limited to efficiency improvements at Town Hall A and B.

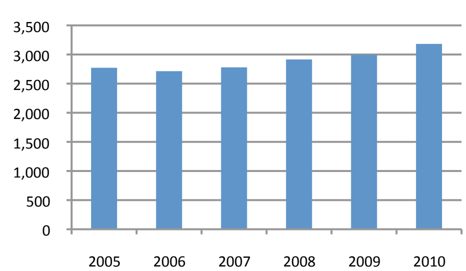
Parks and Rec

Total Emissions (MTCDE):	3,182
Change from 2009:	+6.2%
Percent of Town Total:	7.2%
Estimated Energy Cost:	$617,288
Activities with Energy Use:	Parks and Facilities Fleet Vehicles Outdoor/Sport Lighting
Number of Fleet Vehicles:	7
Average MPG:	15.0
Shared Buildings:	Town Hall B-- 13%

Emissions Profile



Emissions Trend



	Highest Energy Use/Emission Sites	MTCDE
1	WakeMed Soccer Park	416.0
2	Bond Park Community Center	390.2
3	USA Baseball Complex	338.2
4	Bond Park Senior Center	330.4
5	Herb Young Community Center	237.2
6	Cary Tennis Park	225.9

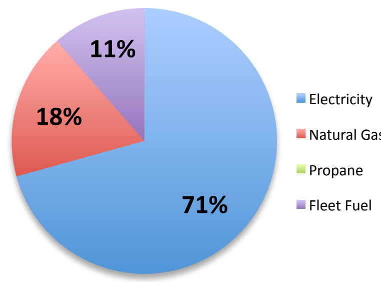
Planning

Total Emissions (MTCDE):	208
Change from 2009:	+3.3%
Percent of Town Total:	0.5%
Estimated Energy Cost:	$33,808
Activities with Energy Use:	Town Hall
Number of Fleet Vehicles:	7
Average MPG:	12.6
Shared Buildings:	Town Hall B-- 14%

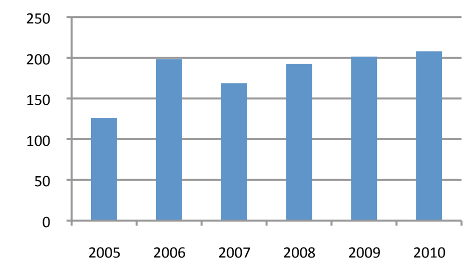
With an available fleet of only 7 vehicles, the majority of the emissions from activities of the Planning Department are the result of shared office space in Town Hall B.

Even so, the 7 vehicle fleet consists mainly of oversized pickups and SUVs. The addition of two midsize pickups in 2010 is a step in the right direction, but more opportunities exist.

Emissions Profile



Emissions Trend

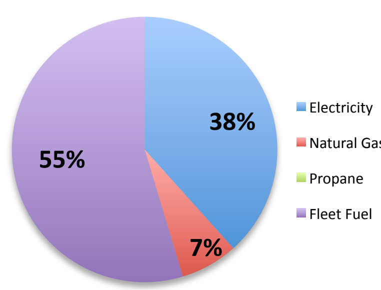


Police

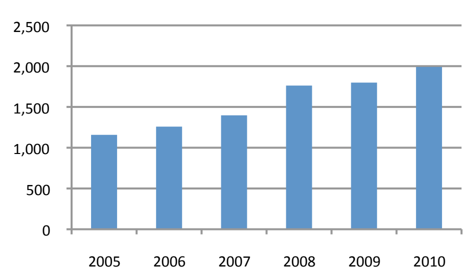
Total Emissions (MTCDE):	1,990
Change from 2009:	+10.7%
Percent of Town Total:	4.5%
Estimated Energy Cost:	$366,498
Activities with Energy Use:	Town Hall
	Firing Range
	Fleet Vehicles
Number of Fleet Vehicles:	136
Average MPG:	11.3
Shared Buildings:	Town Hall C-- 85%

The Police Department fleet has grown considerably in size since 2005, according to fleet records from Public Works. Considering the large share of mobile emissions, the introduction of alternative fuels such as E85 or hybrid vehicles such as the Ford Escape can significantly decrease the departmental totals.

Emissions Profile



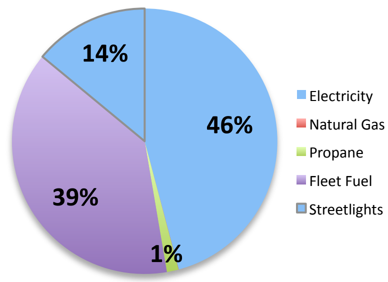
Emissions Trend



Public Works

Total Emissions (MTCDE):	7,629
Change from 2009:	+3.8%
Percent of Town Total:	17.4%
Estimated Energy Cost:	$2,643,435
Activities with Energy Use:	Streetlights and Traffic Signals Various Facilities Fleet Vehicles
Number of Fleet Vehicles:	306
Average MPG:	5.9

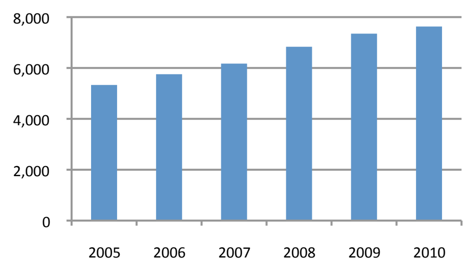
Emissions Profile



Public Works Vehicle Inventory

Count	Division	MTCDE
146	Field Operations	1,013
34	Solid Waste	888
100	Buildings & Grounds	626
13	Recycling	359
9	Fleet	11
4	Public Works Admin	5

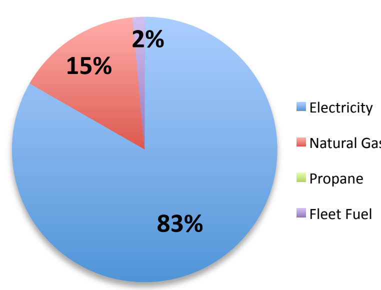
Emissions Trend



Technology Services

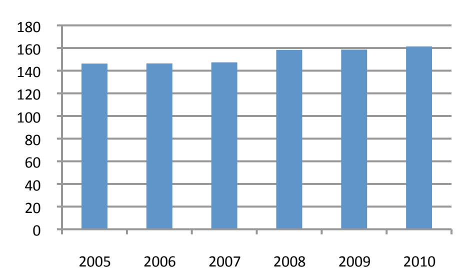
Total Emissions (MTCDE):	161
Change from 2009:	+1.8%
Percent of Town Total:	0.4%
Estimated Energy Cost:	$25,663
Activities with Energy Use:	Town Hall Fleet Vehicles
Number of Fleet Vehicles:	2
Average MPG:	15.3
Shared Buildings:	Town Hall C-- 15%

Emissions Profile



With only 2 vehicles, the majority of energy consumption by the Legislative Department is from the office space in Town Hall C. Thus, the largest reduction opportunities exist in efficiency improvements at Town Hall C, but there also is opportunity to improve the fuel efficiency of the 2-vehicle fleet either with passenger cars or the hybrid Ford Escape.

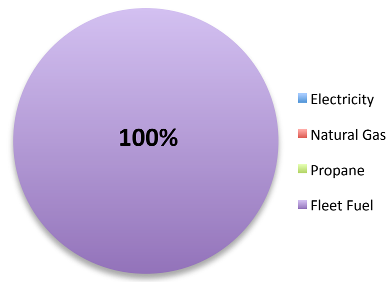
Emissions Trend



Transit

Total Emissions (MTCDE):	923.1
Change from 2009:	+15.3%
Percent of Town Total:	2.1%
Estimated Energy Cost:	$197,944
Activities with Energy Use:	C-Tran Vehicles
Number of Fleet Vehicles:	59
Average MPG:	10.6
Shared Buildings:	None-- contracted service

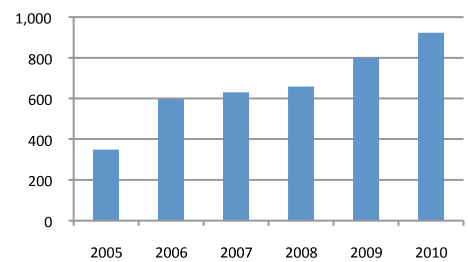
Emissions Profile



Because fuel data within the the Transit fleet has been poorly recorded throughout this study period, there is limited insight into these activities. An annual vehicle count parallels the steadily increasing emissions trend.

Year	Count
2005	20
2006	29
2007	27
2008	28
2009	36
2010	59

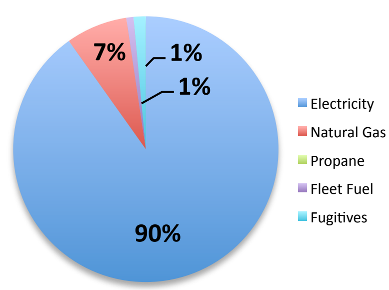
Emissions Trend



Utilities

Total Emissions (MTCDE):	27,043
Change from 2009:	+2.8%
Percent of Town Total:	61.6%
Estimated Energy Cost:	$3,936,989
Activities with Energy Use:	Water Treatment Water Delivery Wastewater Treatment
Number of Fleet Vehicles:	40
Average MPG:	10.8

Emissions Profile



Process	MTCDE
Cary/Apex Water Treatment Plant	7,342
South Cary Water Reclamation	6,120
North Cary Water Reclamation	5,548
Water Intake	2,876
Water Delivery	2,434
Biosolids Dryer	2,025

Emissions Trend