

EXECUTIVE SUMMARY

“When the well’s dry, we know the worth of water”

– Benjamin Franklin (1706-1790), Poor Richard’s Almanac

“Matter can neither be created nor destroyed”

- Law of Conservation of Matter

“The ultimate test of man’s conscience may be his willingness to sacrifice something today for future generations whose words of thanks will not be heard.”

– Gaylord Nelson, former governor of Wisconsin and found of Earth Day

In science class, we all learned the Law of Conservation of Matter. It all seemed so reasonable in that matter will continue to exist and merely change forms regardless of what we do. The part that none of our professors and teachers really touched upon is that, yes, it will change forms, but is it a form that sustains living creatures as we know it? When the matter we use on an everyday basis is converted to carbon dioxide or nitrous oxide, it is still matter; but not matter that we need to sustain our environment, not completely.

One only turn on the television or browse the internet to see that there is a growing concern for our environment and the different environmental issues. We are starting to realize the “value of water”, and we certainly don’t want to wait until “the well is dry”. You will find that there is a cause for greenhouse gas emission and global warming from something as small as the type of propellant on a can of whip cream to Al Gore’s “Inconvenient Truth”. Because of this information overload, it sometimes becomes overwhelming and difficult to discern the greenhouse gas causes and effects. The causes of global warming, ozone depletion, and other greenhouse gas issues are numerous and invisible; so that a lot of us have normalized to it.

In order to find a solution, one must define the problem; this applies to the environment, just as much as it does to everything else. Because of the growing environmental concern, there are numerous publications, spreadsheets, calculation formulas, and other tools to help define the issues and steps to rectify those issues. More and more each day that institutions of higher education and others are realizing the issues and are taking steps accordingly.

In March 2010, we were commissioned by the University of North Carolina at Greensboro to catalog its greenhouse gas emissions (please note that greenhouse gas emissions and carbon foot print, for the purposes and context of this report, will be used synonymously) and provide a report summary of their carbon foot print for fiscal year 2008-2009. The University of North Carolina at Greensboro has been aware and well versed at a lot of the environmental issues. One of those

issues is the carbon foot print that the university creates. Defining the amount of carbon footprint of the university is one of the first steps in defining the environmental issues.

The university has expressed their desire to be carbon neutral by the year 2050, create a carbon action plan by 2015, and full commitment to the American College and University President's Climate Commitment (ACUPCC¹) as issued by the Association for the Advancement of Sustainability in Higher Education (AASHE²).

The purpose and goals of this project is as follows:

1. Research and analyze the different types of calculation software and spreadsheets available for calculating and tracking greenhouse gas emissions, select one, and use for this project.
2. Begin the process of acquiring and consolidating the data to be input into the calculation spreadsheets.
3. Input the initial data as agreed upon by university personnel. There are some data that, because of time constraint, we as a group opted not to include. Refer to chapter on assumptions (Appendix B) for further information.
4. Consolidate the results of the calculated data into a summary report.
5. The calculation spreadsheet is designed to be a dynamic spreadsheet in that it is designed to be updated on an annual basis. Upon completion of the project, this spreadsheet shall be provided to the newly hired Sustainability Coordinator.
6. Upon completion of this project, the university will use the data provided as their baseline year for tracking its green house gas emissions on an annual basis.

It is commendable that the university has opted to begin the steps described above. It is one of the crucial first steps in achieving their goal of carbon neutrality.

¹ American College and University Presidents Climate Commitment; www.presidentclimatecommitment.org

² Associate for the Advancement of Sustainability in Higher Education; www.aashe.org

INTRODUCTION

UNIVERSITY COMMITMENT

Established on February 18, 1891, the University of North Carolina at Greensboro has since been a leader of innovation. As one of the premier schools in the UNC school system and a leader in its local community of the Triad, the University of North Carolina at Greensboro has been committed to utilizing energy efficient and environmentally friendly systems throughout its approximately 128 acre campus that is home to upwards of 20,000 students, faculty, and staff.

In 2010, the university is in the process of beginning its climate action plan and execution of the American College and University President's Climate Commitment (ACUPCC) with the goal of carbon neutrality by the year 2050. This greenhouse gas inventory and report is one of the first steps the university has taken to achieve its climate goals.

METHODOLOGY (BRIEF SUMMARY)

After extensive evaluation and as presented to UNCG for approval, we have opted to adapt the Clean Air Cool Planet (CA-CP³) Greenhouse Gas Inventory calculation spreadsheet. We found that though a lot of the spreadsheets require similar input information, but they vary in the types of output they are able to provide. The Clean Air Cool Planet spreadsheet seems to allow for the most output and output variations that the university has expressed interest. Based on discussions with UNCG and its future climate goals, we agreed that the CA-CP spreadsheet shall be utilized.

The toughest part in an effort such as this is the data acquisition. With the help of all team members, it took most of the three months, but we managed to acquire all the data (data as agreed upon) for this project. The data was then inputted into the spreadsheet. The desired output was then utilized from the spreadsheets and used for the report.

The report is configured to provide the output data described above, provide a brief explanation of the greenhouse concerns, provide comparisons, and provide recommendations.

Our deliverables are the clean air cool planet spreadsheet (in electronic format) and the report (in electronic and hardcopy format). This is a dynamic spreadsheet and process that the university plans to continuously update on an annual basis.

³ Clean Air Cool Planet; www.cleanair-coolplanet.org

PROJECT PARAMETERS

In a large, fast paced project and with a university that has extensive operational scale, interaction with outside entities, and multi-year information, it is important to define the goals and limitations of the data to be utilized for that goal.

After analysis of the available data, we opted to utilize the fiscal year of 2008 to 2009. This fiscal year provided us with the most complete and exemplary data of university operations as compared to the other annual data.

It is important to note that due to the time and information constraint, there are input and output parameters that the university has opted not to include with this initial greenhouse gas inventory (refer to Appendix B for a list of assumptions). Because of the exclusion of this information, there are uncertainties that are inherent in the report that the university understands will be included in future revisions of the spreadsheet and report after it is turned over to the university.

Data not acquired will be filled in by data acquired from Greenhouse Gas (GHG) organization publications. These organizations will be further identified and discussed in this report, and their data highlighted.

WHAT ARE GREENHOUSE GASES?

BRIEF DEFINITION

Numerous chemical compounds in the earth's atmosphere act as greenhouse gases. These gases allow sunlight to penetrate the atmosphere. When the sunlight strikes the earth's surface, part of its energy is absorbed and the rest is re-radiated to space as long wave radiation or infrared (heat). Greenhouse gases then absorb the infrared radiation and trap the heat in the atmosphere (figure 1). This process of heating the earth's atmosphere as a result of the action of the greenhouse gases is known as the greenhouse effect.

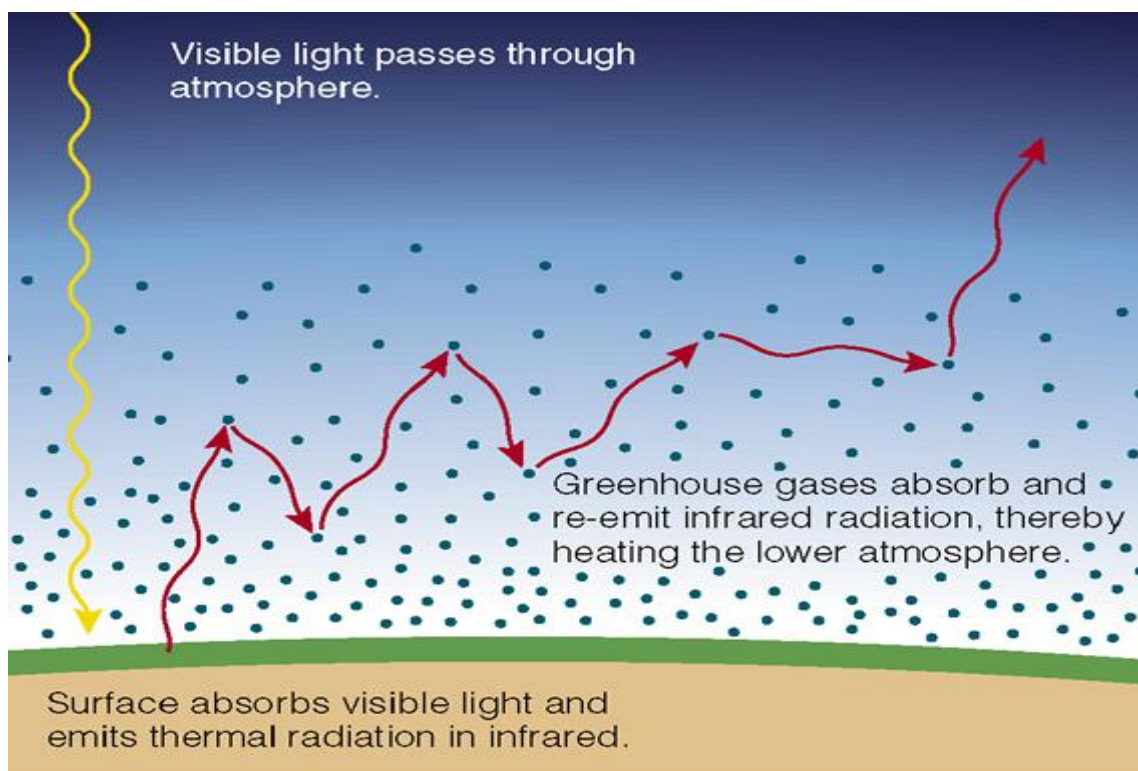


Figure 1: Greenhouse Effect

The greenhouse effect is a natural phenomenon without which the earth would not be habitable. Several naturally occurring gases including water vapor, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and ozone (O₃) exhibit the greenhouse effect. Carbon dioxide (CO₂) is the most important greenhouse gas because its atmospheric concentration is increasing rapidly due to anthropogenic activities such as the burning of fossil fuel. The concentration of CO₂ in the

atmosphere is reported to have increased from 280 ppm to 379 ppm between the pre-industrial era and the year 2005 as noted in the 2007 IPCC Report⁴.

In the absence of CFCs and ozone, the rise in CO₂ has contributed approximately 70% of the present greenhouse effect and the remaining effects are due primarily to CH₄ (24%) and N₂O (~6%) as noted in the *Global Warming: The Complete Briefing*⁵. In addition to natural occurring GHGs, a plethora of substances containing fluorine, chlorine, and bromine also form greenhouse gases; however, these gases are mostly generated as a result of industrial activities.

HUMAN ACTIVITIES AND CLIMATE CHANGE

Concerns about human activities leading to GHG emissions and their significant influence on global climate change were first raised in the 1960s. Climate change is defined as “fluctuation in the temperature, precipitation, wind, and other elements of Earth’s climate system”⁶. The Intergovernmental Panel on Climate change attributes the climate change over time to natural variability or to human activities. Since the beginning of the industrial revolution nearly 250 years ago, human activities such as the burning of fossil fuels, deforestation and various agricultural and industrial practices have affected the natural balance of greenhouse gases, thereby enhancing the warming of the earth’s atmosphere⁷.

Despite the efforts and the attention to curb the problem of Global Warming as a result of the greenhouse effect, greenhouse gases continue to grow in United States and the world as a whole. According to Energy Information Administration, greenhouse gases, mostly carbon dioxide, were increased by 1.4% in 2008 as a result of anthropogenic activities⁸. It is in the light of this that most institutions including UNCG have decided to track their contribution and to develop measures that can lead to the reduction of fossil fuel consumption and consequently greenhouse gas emissions.

⁴ IPCC(2007) Report

<http://engineers.ihs.com/news/eu-en-greenhouse-gases-5-07.htm>

⁵ Houghton, J. T. (1997). *Global Warming: The Complete Briefing*. Port Chester, NY, USA, Cambridge University Press

⁶ University of New Hampshire (1990-2003), Greenhouse gas emissions inventory

⁷ Adam, R. et al. (2003). *Greenhouse Gas Emissions inventory for Pennsylvania Phase I report*. Pennsylvania.

⁸ Energy Information Administration (EIA) 2008, Emissions of Greenhouse Gases in the United States 2007; Energy Information Administration Office of Integrated Analysis and Forecasting U.S. Department of Energy Washington, DC 20585
[http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/0573\(2007\).pdf](http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/0573(2007).pdf)

GREENHOUSE GAS INVENTORY

This report tracks the anthropogenic, or man-made, greenhouse gas emissions for the University of North Carolina at Greensboro (UNCG) campus for the fiscal year of 2008-2009.

On December 11, 1997, the *Kyoto Protocol* was adopted by the *United Nations Framework Convention on Climate Change* (UNFCCC) in Kyoto, Japan, and entered into force on February 16, 2005. The UNFCCC is an international environmental with the goal of achieving “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with climate systems”⁹. The *Kyoto Protocol* is a set of guidelines and regulations, signed by delegates of the UNFCCC, aimed at fighting global warming. See Figure 2 below for countries that have signed the Kyoto Protocol.



Figure 2: Kyoto Protocol Participation as of June 2009¹⁰. The countries shaded in dark green are countries that have signed and ratified the treaty, the grey have not yet decided to sign the protocol, and the red are countries with no intention to sign and ratify.

⁹ Article 2 of the United Nations Framework Convention on Climate Change (November 15, 2005).

¹⁰ Kyoto Protocol Ratification (June 2009)

The *Kyoto Protocol* has set guidelines on the measurement of what is called the *Kyoto Six*¹¹. The *Kyoto six* defines the most common occurring greenhouse gas emissions (see table 2 below).

| <i>GREENHOUSE GAS EMISSION</i> | <i>ATMOSPHERE LIFETIME (YEARS)</i> | <i>GLOBAL WARMING POTENTIAL (100 YEARS)</i> |
|--|------------------------------------|---|
| Carbon Dioxide (CO ₂) | 50-200 | 1 |
| Methane(CH ₄) | 9-15 | 21 |
| Nitrous Oxide (N ₂ O) | 120 | 310 |
| Hydrofluorocarbons (HFC) | 15 | 1,300 |
| Perfluorocarbons (PFC) | >48 | 3,260 |
| Sulfur Hexafluoride (SF ₆) | 3,200 | 23,900 |

Table 2: Global Warming Potentials and Atmospheric Lifetime of Several Greenhouse Gases¹²

The *Kyoto Protocol* is generally seen as an important first step towards a truly global emission reduction regime that will stabilize GHG emissions, and provides the essential architecture for any future international agreement on climate change.

Since the inception of the Kyoto Protocol, multiple organizations have been formed to provide new additional international framework for the negotiation and ratification of the emissions reduction; once such organization is the *Intergovernmental Panel on Climate Change* (IPCC)¹³ which was

¹¹ Kyoto Protocol; www.unfccc.int/kyoto_protocol

¹² Energy Information Administration (2008), Emissions of Greenhouse Gases in the United States, Department of Energy, Information Administration, 2008.

¹³ Intergovernmental Panel on Climate Change (IPCC) (1996), Guidelines for National Greenhouse Gas Inventories 1-3.

established by the United Nations Environmental Programme¹⁴ (UNEP) and the World Meteorological Organization¹⁵ (WMO).

Since the different emission sources utilize different units of measurement, it is hard to compare each source. The Kyoto Protocol and IPCC have created standards as to how greenhouse gases are tracked and measured. A common means of measurement is to convert the emission sources to Metric Tons of Carbon Dioxide Equivalent (MTCDE). The emissions used for our inventory have been converted to MTCDE using the guidelines set forth by the *IPCC*

The University of North Carolina at Greensboro's emission sources have been categorized into three main scopes in accordance with the World Resources Institute (WRI)/World Business Council for Sustainable Development (WBCSD) classification¹⁶.

SCOPE DEFINITION:

Scope 1: Direct emissions

These include all direct GHG emissions produced by facilities owned and controlled by the organization (e.g., production of electricity and steam, vehicle fuel consumption and fugitive emissions).

Scope 2: Indirect emissions from purchased electricity and steam

These include all emissions associated with purchased electricity. It is important to note that UNCG does not purchase steam from outside sources; so it is not included as part of this scope. Scope 2 emissions physically occur at the facilities where the energy was generated and not at the user site.

Scope 3: All other indirect emissions

This includes all emissions from outsourced activities. Such emissions may have resulted from the activities of community members in the institution but occurred at sources owned and controlled by another organization (e.g. air travel, solid waste management, commuting activities).

We analyzed the different GHG emission sources, and have categorized them under each scope as shown on Table 2 below.

¹⁴ United Nations Environmental Programme; www.unep.org

¹⁵ World Meteorological Organization; www.wmo.int

¹⁶ WBCSD/WRI, <http://www.wbcsd.org/web/publications/ghg-protocol.pdf>

Table 2: University of North Carolina at Greensboro Greenhouse Gas Emission Scope

| Scope 1 | Scope 2 | Scope 3 |
|---|-----------------------|--------------------------------|
| Other On-Campus Stationary (Distillate Oil#(1-4), Natural Gas, Propane) | Purchased Electricity | Faculty / Staff Commuting |
| Direct Transportation | * | Student Commuting |
| Refrigerants & Chemicals | * | Directly Financed Air Travel |
| Agriculture | * | Other Directly Financed Travel |
| * | * | Study Abroad Air Travel |
| * | * | Solid Waste |
| * | * | Wastewater |
| * | * | Paper |

METHODOLOGY

BRIEF DESCRIPTION

The methods used to acquire and analyze UNCG's greenhouse gas emissions were adapted from the guidelines provided by the IPCC.

The emission inventory was calculated using the Clean Air Cool Planet¹⁷ (CACP) calculation spreadsheet. The CACP spreadsheet is a spreadsheet created by the Clean Air Cool Planet organization. It is one of the widely used spreadsheets for GHG inventory.

This spreadsheet converts energy waste inputs to GHG output using emission factors that are unique to the user's particular locality. The input to the spreadsheet includes Agriculture, Refrigeration/Chemicals, Energy Sources, Transportation and Solid Waste.

This inventory accounts for energy used and solid waste generated within the University limits. For example, emissions resulting from electricity used in UNCG but produced elsewhere, as well as the decomposition of waste generated in UNCG and disposed at a landfill at another location, are utilized for in this inventory.

Data used in this inventory was collected from various sources on campus over a period of two months via group meetings, individual meetings, data exchange, and limited field analysis.

ELECTRICITY AND NATURAL GAS

The types of energy sources that compose a utility's electricity generation mix have a significant impact on greenhouse gas emissions. For instance, a coal fired power plant has different emission factors than those from gas turbines or renewable energy sources such as solar, wind, or hydroelectric power. The CACP spreadsheet calculates emissions from electricity by using emission coefficients, which indicate the amount of GHG emissions produced per unit of source energy used. The emission coefficients employed by the CACP are standard for different fuel types; however, they change for electricity consumption depending on the fuel mix used to generate the electricity in a region in which a University is located.

The software uses regions defined by the United States Environmental Protection Agency¹⁸ (USEPA) and by the North American Electricity Reliability Corporation¹⁹ (NERC) to decide the

¹⁷ Clean Air Cool Planet (CA-CP); www.cleanair-coolplanet.org

¹⁸ United States Environmental Protection Agency (USEPA); www.epa.gov/cleanenergy

¹⁹ National American Electricity Reliability Corporation (NERC); www.nerc.com

TRANSPORTATION

The transportation sector assessment takes care of both commuter patterns and university fleet emissions. Fleet emissions were determined from the total amount of gasoline, diesel fuel, natural gas, and electricity consumed by university vehicles. UNCG relies primarily on gasoline-fueled vehicles in their fleet. The commuter emissions were determined through an estimation of total vehicle miles traveled (VMT) for an average faculty, staff, and student's daily commute using the distance from the center of their home zip code from the center of UNCG. The VMT was used along with the software's standard vehicle fuel efficiency measures to determine the total amount of gasoline consumed and the resulting GHG emissions. Among all the data collected the commuter distance is one with high uncertainty.

SOLID WASTE

Solid waste generated by UNCG also contributes to its GHG emissions. The University does not have any waste treatment facility thus the solid waste generated is disposed at Uwharrie Landfill. The Landfill has methane recovery system but the capture methane is only flared off. For the software to calculate solid waste emissions, we entered total tonnage of waste sent both to landfill.

REFRIGERANTS

The refrigeration/chemicals category consists of refrigerant emissions of various coolants that are used for university refrigeration equipment, like chillers, refrigerators, etc. These refrigerants are mainly typical readily available refrigerants like HFC-134A, HFC-404A, R22, R12, and SF6. The refrigerant data collected was entered into the spreadsheet to calculate the associated greenhouse gas emissions.

AGRICULTURAL

The agriculture category looks at the total number of methane producing animals under the care of the university and the emissions from organic and synthetic fertilizers. Since UNCG has no farm, the only source of emissions assigned to this sector was the emission produced by the organic and synthetic fertilizers purchased and used by the university. The percentage of nitrogen in the organic fertilizer was assumed to be 4.1% that is the mean percentage of nitrogen possess by organic fertilizers since the actual amount was unknown. Though the percentage of nitrogen contained in the synthetic fertilizers bought were provided. There were a range of fertilizers purchased by UNCG during the base year thus mean percentage of nitrogen was used.

RESULTS

EMISSIONS BY SOURCE

The total GHG emissions produced by UNCG for the fiscal year 2008-2009 are 88,138 MT-CO₂e.

Purchased electricity is the largest source of GHG emission produced by UNCG. Its contribution to the total emissions is approximately 48% as shown in Figure 3. This may be due to the fuel mix of Duke Energy which depends mostly on coal to supply energy to Greensboro and the state of North Carolina as a whole. According to 2008 energy generation statistics fossil fuel, mostly coal, contributed about 53% of the total energy supplied by the Duke Energy to North Carolina. Coal is known to be among the dirtiest source of energy with high contribution to GHG. Considering electricity as the major source of energy used by UNCG, we find the energy utilization index²¹ of the university is 53850 BTU/SF/YR.

Distillate oil²² (#1-4), natural gas, and propane are the second largest contributors of GHG emissions produced by UNCG. Its contribution is 21% of the total emissions. This may be due to severity of weather or/and inefficiencies in the boilers since natural gas is the main source of heating fuel on the campus.

The third largest source of GHG emissions produced by UNCG is student commute (see figure 3). The student commute contributed 20% of the GHG emissions for the 2008-2009 Fiscal Year. The reason may be long commuting distance and high number of students living outside the school campus. Another source worth mentioning is faculty/staff commute. The faculty/staff commute contributed approximately 12% of the total GHG emissions for the 2008-2009 fiscal year.

The detailed breakdown of the GHG emission in the university is depicted in the Figure 4 below. Emissions from refrigerants, solid waste, direct transportation and other direct financial travel accounted for a total of 3%. Table 3 below shows the demographic emission summary of UNCG.

²¹ Energy Star; www.energystar.gov

²² Distillate oil no. 1 to 4 – These are lighter fuel oils used for heating and vehicle fuel. No. 1 is for heating. No.2 is used for vehicles. No. 3 and 4 are typically used for heating, and are rarely used. *National Park Service – Fuel Oil*; www.nature.nps.gov

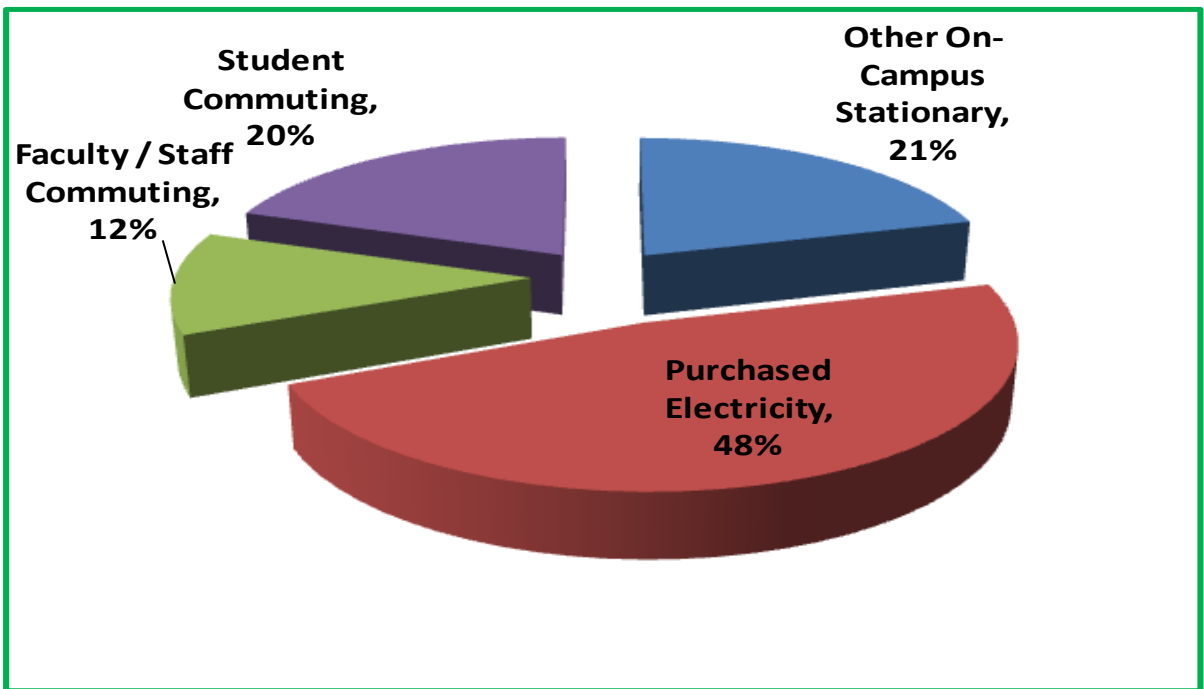


Figure 3: Contribution of Major Sources to University Emissions for 2008-2009 Fiscal Year; total GHG emissions = 88,138 MT-CO₂e

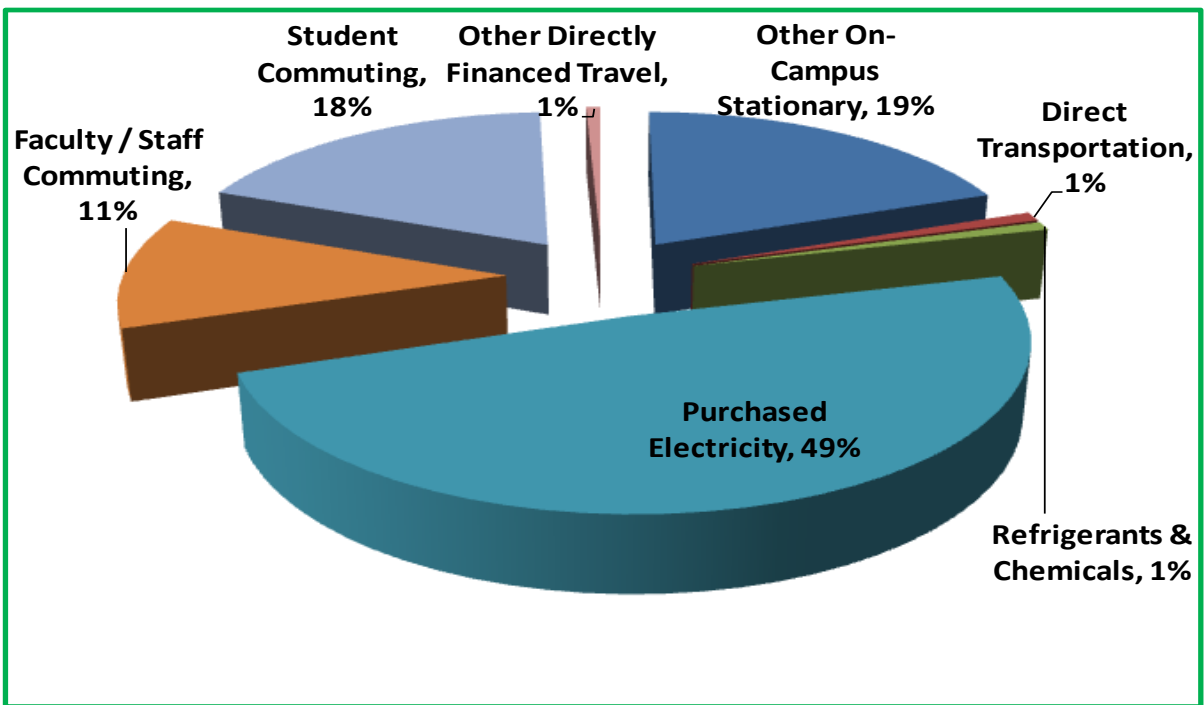


Figure 4: A Detailed Breakdown of University Emissions by Source for the 2008-2009 Fiscal Year; total emissions=88,138 MT-CO₂e

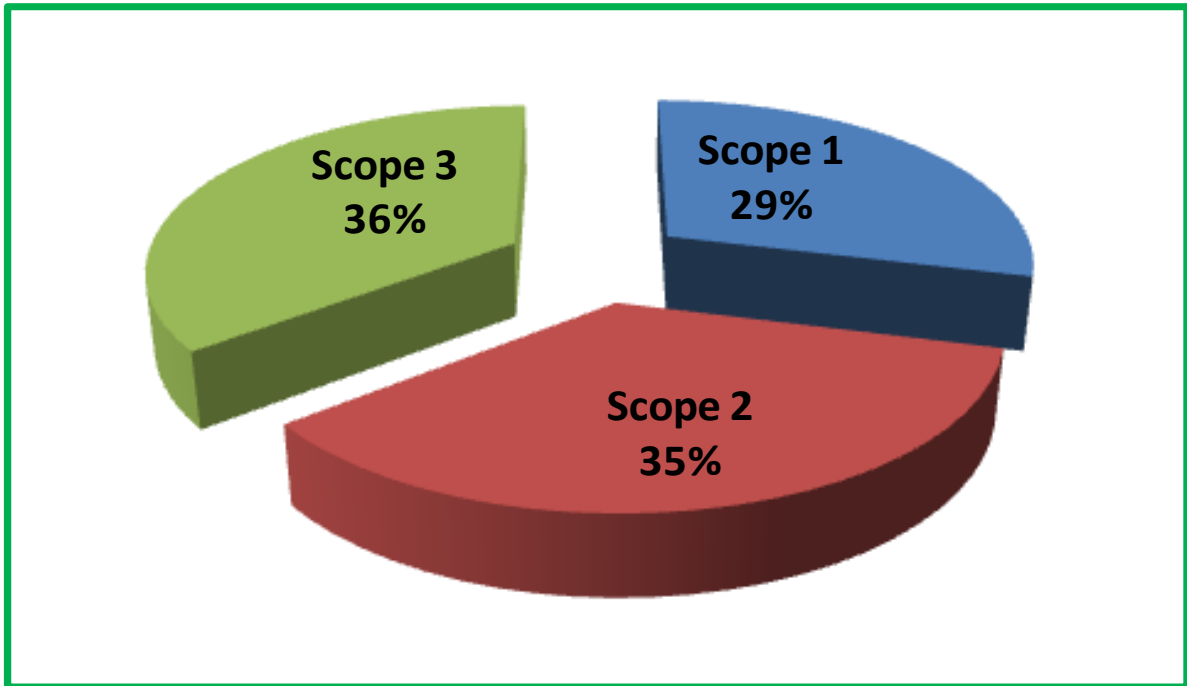


Figure 5: Energy Consumption per Scope

Table 3: University Emissions by Selected Demographic

| | |
|--|----------------|
| Emissions Per Operating Budget (MT-CO₂e/\$) | 0.00029 |
| Emissions Per Research Budget (MT-CO₂e/\$) | 0.00604 |
| Emissions Per Energy Budget (MT-CO₂e/\$) | 0.01211 |
| Emissions Per Student (MT-CO₂e/student) | 5.76 |
| Emissions Per Total Building Area (MT-CO₂e/sf) | 0.0158 |
| Emissions Per Total Research Area (MT-CO₂e/sf)..... | 0.60821 |

TOTAL ENERGY CONSUMPTION

The total energy consumption by the University of North Carolina at Greensboro for the fiscal year 2008-2009 was 1,191,972 MMBtu as shown in Table 4. UNCG relies heavily on fossil fuel consumption for its energy needs. Almost all the energy consumed in the Fiscal Year under consideration comes from fossil fuel. The percentage of energy responsible for the emissions in the three scopes described above is depicted in Figure 5. Similarly, scope 2 consisting of purchased electricity has the largest energy consumption.

COMPARISON

- INSTITUTION: COLLEGE OF WILLIAM AND MARY (CWM)
 - Williamsburg, VA
 - 1,200 acre campus
 - 2008 GHG Inventory
(Published Aug. 13, 2009; www.wm.edu/sites/sustainability/documents/ghgaudit.pdf)
 - Student Population: 12,000
 - Total GHG Emission: 73,794 MT-CO₂e
 - GHG Emission per Building Area: 0.0225 MT-CO₂e/sf

PEER COMPARISON

| | <u>UNCG</u> | <u>CWM</u> |
|--|-------------|------------|
| Emissions/Student (MT-CO ₂ e/student) | 5.76 | 6.15 |
| Emissions/Bldg Area (MT-CO ₂ e/sf) | 0.0158 | 0.0225 |