Carleton's Green House Gas Emissions at Carleton College: A Complete Inventory for 2004-2005 with Extrapolations Back to 1990.

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ABSTRACT:

Carleton completed a greenhouse gas (GHG) inventory of all possible sources of emissions at Carleton. GHG emissions were assigned values relative to their global warming potential. Carbon-Dioxide has a set value of one, and all other gases are based on this. Emissions reported in this inventory are in metric tons of Carbon-Dioxide equivalent emissions. In the past 14 years, GHG emissions from Carleton have increased by over 39%. The major sources of emissions are purchased electricity, 55%, and stationary fuel use for heating 36%. Transportation and refrigeration account for 9% and less then 1% respectively. Agriculture and potential offsets were negligible. Emissions per student have increased by 40% since 1990. Emissions have increased even when taking into account the increased building growth of this time. Heating emissions per square foot have remained relatively constant, but electrical emissions have increased per square foot. If Carleton were to adopt the Kyoto protocol on GHG emissions, it would have to reduce its emissions by over 47% by 2012. Carleton's GHG emissions are similar to those of other comparable colleges and universities.

INTRODUCTION:

According to the Environmental Protection agency, the tier one environmental problems of most consequence are: habitat destruction causing loss of biodiversity, animal extinction and global climate change. Global climate change in the form of global warming is the most destructive environmental problem; it has the potential to cause massive habitat destruction, loss of bio-diversity and profound harm to all humans.

To determine the Global Warming Impact (GWI) of Carleton it is necessary to inventory all of Carleton's Green House Gas (GHG) emissions. Creating a detailed GHG inventory is a way to see the total environmental effect and GWI of Carleton. The GWI of the Carleton community does not simply include the gas we use to heat and the electricity we use for power; Carleton's GWI includes all harms done by emitting GHGs from **all** sources at Carleton.

Carleton's Facilities office determined that it is important and valuable to understand the total GWI of Carleton College. Understanding Carleton's GWI will give students, faculty and administrators a context for making environmental decisions for Carleton's future. The data recorded in our inventory will form the basis for a future environmental policy or for the adoption of the Kyoto treaty. Carleton's GHG inventory includes all direct emissions created by Carleton, Carleton activities and the Carleton community.

A proper GHG inventory looks at all sources of emissions on a campus. Electricity consumption and fuel consumption are the largest sources of GHG emissions, but they are not the only sources. Chemical use, solid waste and nitrogen emissions from fertilizer all play a part in Carleton's GHG emissions. Another large source of greenhouse gas emissions is transpiration emissions caused by Carleton activities. Some may argue that transportation is not relevant to Carleton's GHG impact; however, facilities feels that it is an important part of Carleton's emissions and that transportation directly related to Carleton activities should not be omitted from our GHG Inventory.

GLOBAL WARMING FACTS AND BACKGROUND:

Global warming has the potential to affect all aspects of the planet, destroying the fragile balances of ecosystems throughout the word. Global warming will affect all people, all ways of life, and all plants and animals throughout the world. The planet earth has always gone though temperature cycles, from ice ages to el-Niño. Temperature in parts of the planet naturally fluctuates, sometimes for thousands of years, other times for only a few months. Hurricanes, storms, tornadoes, ice storms, blizzards and flooding can all be caused by temperature variations. What makes global warming different is man's influence on the environment, the impact it will have on man and the speed at which the planet is warming.

It is clear that there is no longer any debate on global warming. Most of the reports questioning global warming are by scientists working for those who stand to lose if action to stop global warming is taken, and a few of these recent studies were shown to have inaccuracies in data collection and/or analysis. What is still up for debate are the affects that global warming may have on the planet. This section will provide a very basic background on current accepted theories and facts on global warming. The following are a few additional sources for more detailed information on global warming.

BACKGROUND SOURCES:

1. National Geographic report, September 2004, "Global Warming: Bulletins From a Warmer World" Pages 2-75.
2. US EPA, State of Minnesota GHG Inventory: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/JSIN5DQSZ8/$file/MNSummary.PDF
3. US EPA Global Warming Site: http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html
4. Intergovernmental Panel on Climate Change: http://www.grida.no/climate/ipcc_tar/

The definition of a GHG is a gas that contributes to global warming -- a gas that causes heat to be reflected and remain insulated within the planet without being radiated out, or that increases the amount of heat absorbed by the planet. The most abundant natural GHG in the atmosphere is water vapor, followed by carbon dioxide. There has always been a natural greenhouse effect on earth; the greenhouse effect makes the planet habitable for humans. What scientists are concerned about is artificially changing the balance of gases in the atmosphere, causing the planet to unnaturally increase in temperature. This increase comes from both from more sun energy being let into the planet (decreases in the ozone layer) and keeping that heat in (increasing the concentration of CO^2 for example). GHG emissions can also affect the atmosphere in many ways; some molecules increase warming by themselves (such as CO^2) and others combine with existing molecules (such as CFCs breaking up ozone molecules) to warm the planet.

Table 1: Global atmospheric concentration (ppm unless otherwise specified), rate of concentration change (ppb/year) and atmospheric lifetime (years) of selected greenhouse gases.

Atmospheric Variable	CO_2	CH_4	N_2O	SF_6^a	CF_4^a
Pre-industrial atmospheric concentration	278	0.700	0.270	0	40
Atmospheric concentration (1998)	365	1.745	0.314	4.2	80
Rate of concentration change^b	1.5^c	0.007^c	0.0008	0.24	1.0
Atmospheric Lifetime	50-200^d	12^e	114^e	3,200	>50,000

[1]

[1] **Table 1:** US EPA, Greenhouse gases and Global warming potential values http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUM9T/$File/ghg_gwp.pdf

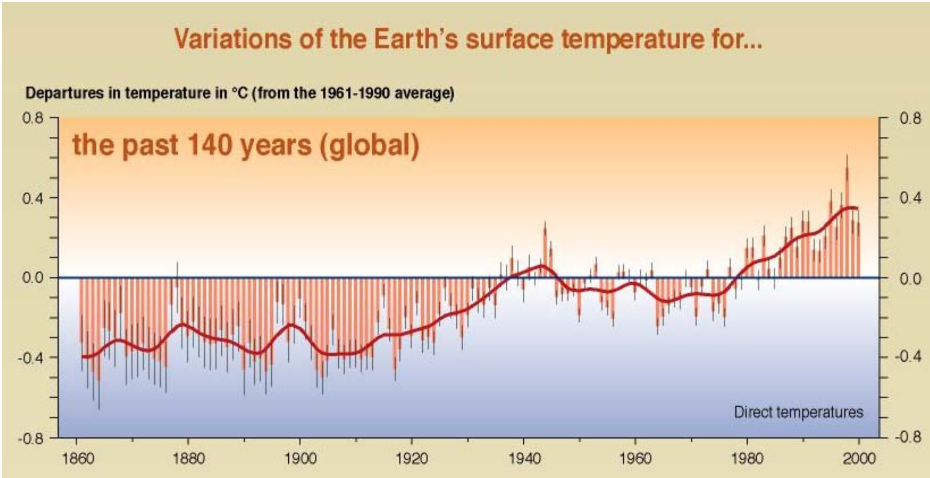

Figure 1: The figure to the left shows the average temperature from 1860 to 2000. What is evident is the dramatic rise in northern hemisphere temperature in the past 30 years. The source of this graph is the Intergovernmental Panel on Climate Change 2001 report.[2]

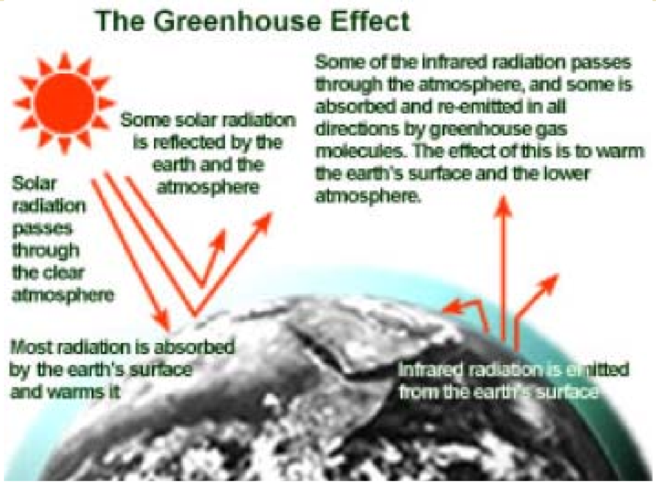

Figure 2: The Diagram to the left is a overview from the US Environmental Protection Agency of the Green House effect.

In the past 150 years the concentration of Carbon Dioxide in the atmosphere has risen by about 30%. Nitrous Oxide and Methane, two other green house gases have also increased during this same time period. In 1995 the United States released more GHG per person then any other country in the world[3]. In a report published in 2001, the IPCC concluded that "most of the observed warming over the last fifty years is likely to have been due to the increase in greenhouse gas concentrations.[4]"

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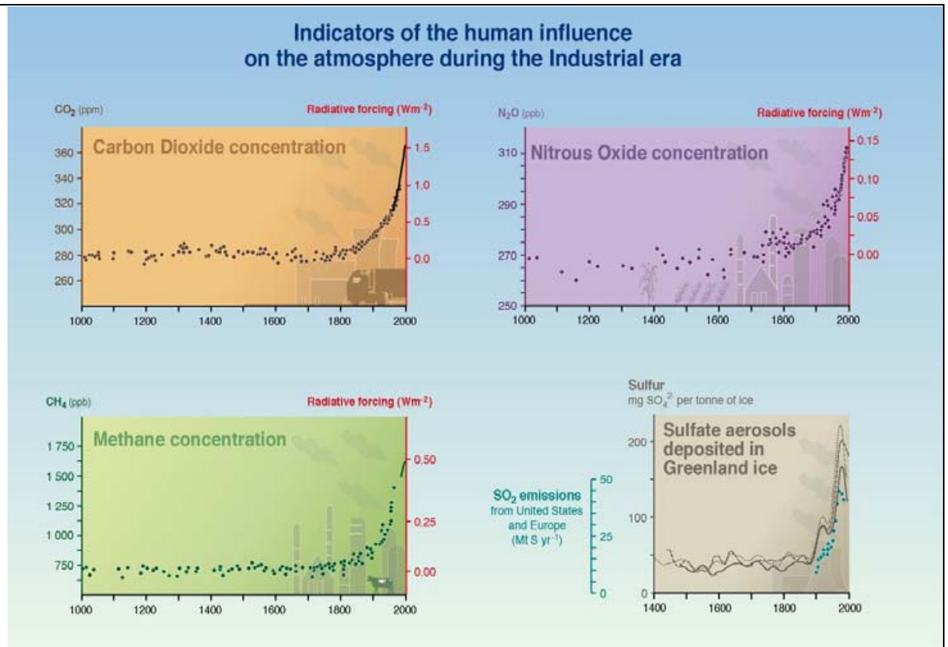
[2] **Figure 1:** IPCC Figure 2.3 http://www.ipcc.ch/present/graphics/2001syr/large/05.16.jpg
[3] **Figure 2:** US EPA: http://yosemite.epa.gov/oar/globalwarming.nsf/content/emissionsindividual.html
[4] IPCC Third Assessment Report: Climate Change 2001

Figure 3:[5] Shows the atmospheric concentration of GHG in the past 1000 years. The effect of Man's industrialization (past 200 years) on the concentration of GHG emissions in the atmosphere is clearly evident.



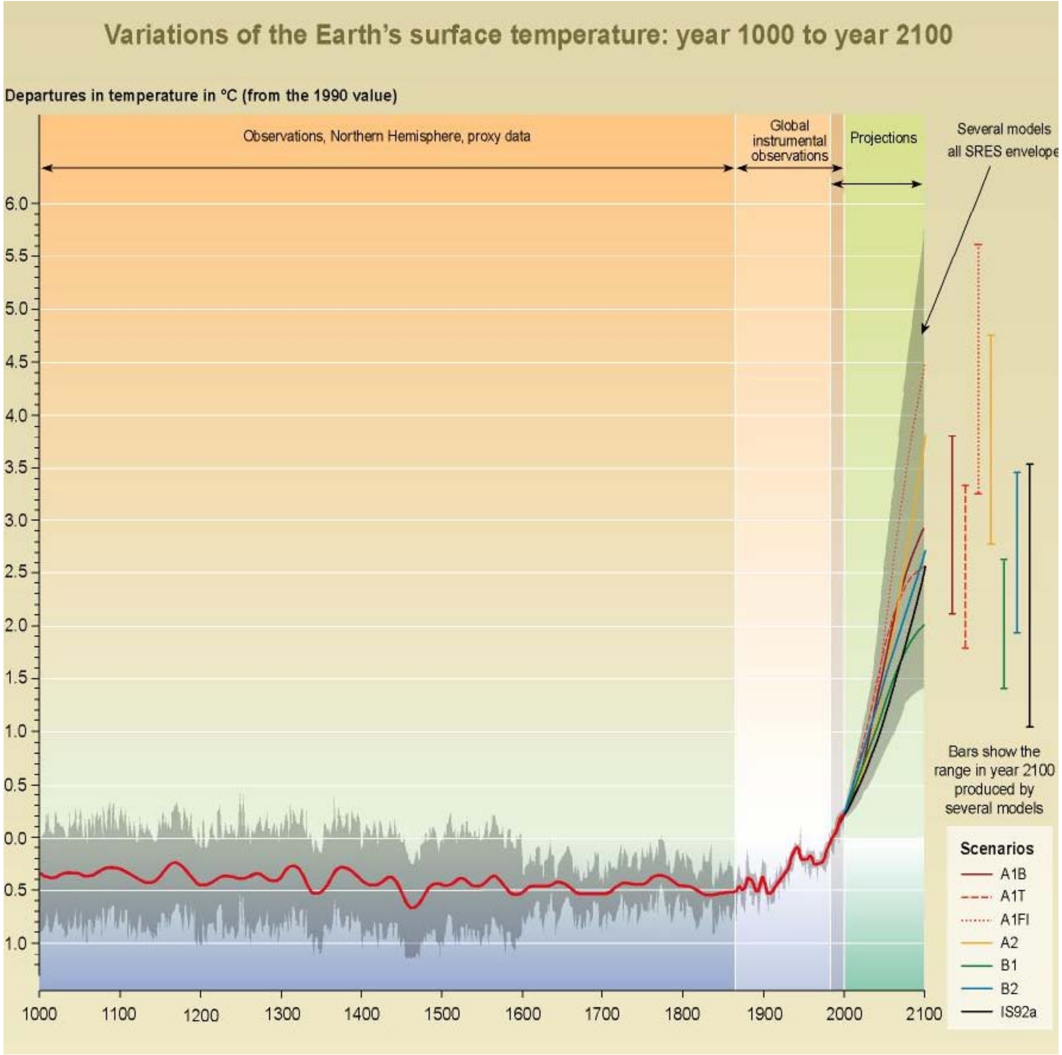
Carbon dioxide is released when fossil fuels are burned. Humans have always released CO^2 by fire, but burning biomass (wood and plants) releases no more CO^2 then is absorbed by the biomass in its growth. Methane and Nitrous Oxide are released by modern day agricultural practices and by burning some fuels. **Figure 3** leaves little doubt as to the effect man is having on the atmospheric concentrations of these gases. This compositional change in the atmosphere has been accompanied by a .8ºC increase in the average world temperature in the past 140 years. There are several parts of the world where glaciers have existed for millennia that are now almost completely melted; global sea levels are already starting to rise.

It is unknown what the future climate will be, how much it will warm and what effect it will have on man. A lot of the future depends on what action we take toady. Do we cap emissions at today's level – which will slow down the increase in GHG in the atmosphere, but not stop their rise? Do we aim to continually reduce emissions each year as technology advances to eventually become carbon neutral (this would stabilize GHG in the atmosphere but not reduce them)? Or do we continue with no action -- a continual acceleration of increases in atmospheric GHG emissions? The following figure (**Figure 4**) from the Intergovernmental Panel on Climate change shows several predicted paths of

[5] **Figure 3:** IPCC Figure 2.1 (SPM-2) http://www.ipcc.ch/present/graphics/2001syr/large/02.01.jpg

future average temperatures, none of them predicting a global warming increase of less then 2ºC, even with reductions in GHG emission rates. The temperature will continue to rise for sometime even after we start to reduce our GHG emissions.

Figure 4: [6]



Global warming is a global problem -- GHG released by Carleton affect those in throughout the world just as they affect us here in Minnesota. Before we can take any steps to reduce the GHG that cause global warming, we must know what gases we emit and how we emit them. The following Carleton GHG inventory was conducted to answer the what and how of Carleton's GHG emissions.

[6] **Figure 4:** IPCC Figure 9.1 http://www.ipcc.ch/present/graphics/2001syr/large/05.24.jpg

HOW TO CALCULATE GREEN HOUSE GAS EMISSIONS:

Green House Gas emissions include several different chemicals and compounds. Because GHG emissions affect the atmosphere in various ways, it is necessary to put all emissions into a similar context to compare and sum up the total harm of GHG emissions. All GHG emissions are calculated to have a global warming potential (GWP). The GWP of a gas factors in how much heat-absorbing ability it has, what molecules it combines with and the decay rate of each gas.[7] Each GHG gas is compared to Carbon Dioxide (CO^2) and assigned a GWP relative to (CO^2). CO^2 is the set base molecule and is assigned a GWP of 1. Other gases are calculated based on the CO^2 value of 1. For example, methane has a GWP 23 times that of CO^2, so it is given a value of 23. The hydro-fluorocarbon HFC-23 (used in refrigeration) has a GWP of 12,000.

Gas	Atmospheric Lifetime	GWP (100 Year)
Carbon Dioxide (CO_2)	50-200	1
Methane (CH_4)	9-15	21
Nitrous Oxide (N_2O)	120	310
HFC – 134A	15	1,300
HFC – 404A	> 48	3,260
Sulfur Hexafluoride (SF_6)	3,200	23,900

Table 2: Some Green house gasses and their GWP[8]

Using the GWP of each gas, it is possible to convert emissions of each gas into equivalent Carbon Dioxide (eCO^2) emissions to create a value that can be added together. For example, 1 metric ton of emitted CO^2 + 1 metric ton of emitted methane is equal to the emission of 24 metric tons eCO^2 (1 ton CO^2 = 1 ton eCO^2, 1 ton methane = 23 tons eCO^2, 1+ 23 = 24 eCO^2). Carleton used the Global Warming Potential of each gas to covert emissions into carbon dioxide equivalents which is how we report the results of our inventory. One metric ton of CO^2 is equal to 2,200lbs of CO^2. One metric ton of CO^2 would approximately fill the volume of a common American house – a 2,000sq ft house with 9ft high ceilings.

[7] Intergovernmental Panel for Climate Change (IPCC): http://www.grida.no/climate/ipcc_tar/wg1/247.htm

[8] **Table 2:** Inventory of US Greenhouse Gas Emissions and Sinks: 1990-1998, US EPA, 2000 http://www.epa.gov/globalwarming/publications/emissions/us2000/executive_summary.pdf

CARLETON'S GHG INVENTORY PROCEDURE:

Carleton conducted its GHG inventory with the procedures laid out by the non-profit organization Clean Air - Cool Planet (CA-CP).[9] CA-CP uses the protocols and GWP established by the Intergovernmental Panel on Climate Change (IPCC) for GHG Calculations. The CA-CP program inventories all six main global warming causing types of gases outlined in the Kyoto treaty. CA-CP designed a program for colleges and universities to conduct a GHG Inventory. Carleton used the CA-CP eCalculator v 4.0 program. Using the CA-CP program provides a standard method to calculate GHG emissions and to conduct our GHG inventory. This will allow us to compare Carleton to other schools that have conducted their own GHG inventories. The CA-CP program is a series of Microsoft Excel™ spreadsheets that request the data of all possible sources of GHG emissions. The CA-CP program uses data for fuel used, electricity purchased, transportation, solid waste, refrigeration, agriculture and emission offsets. The program calculates the emissions released for each input data, the GWP of each emission and then converts all of the emissions into Carbon Dioxide equivalents.

Most of the work done to conduct Carleton's GHG inventory was the acquisition of required data and the calculation of inputs from what data was available. Carleton worked to collect as much data as possible for the years 1990 to 2004; however, most data was only available for the fiscal year 2004-05. In this case, figures were extrapolated back for previous years. Fiscal year data was entered under the first calendar year of the fiscal year in the program (i.e. fiscal year 2004-05 entered as year 2004). Carleton worked to include as much back data as possible to determine emission trends, which will create a foundation for a future energy policy.

The next section details the exact method(s) used to acquire and calculate each of the required data inputs for all sources of emissions.

[9] http://www.cleanair-coolplanet.org/for_campuses.php located in NH and CT.

Institutional data was collected from sources around campus; complete data for full time students, off-campus study students (entered as summer school students), faculty[10], staff, building space and operating budget were acquired from 1990-2004; energy budget data was acquired from 1996 to 2004. All data in this section was entered for the fiscal year, with the start of the fiscal year being the year the data was entered. Carleton did not differentiate between research space and the general campus.

Electricity data was available for each calendar year back to 1990 and was entered in the electricity section. The electricity region was selected as MAPP, which includes Minnesota. The CA-CP program has historical emissions factors for electricity produced in this region. Carleton knows the fuel makeup that our energy company, Xcel, uses to produce electricity -- (Excel Minnesota state averages): 54% Coal, 25% Natural Gas, 10% Nuclear, 4% Hydro, 3% Oil, 3% Wind and the rest Refuse-Derived Fuel. Carleton used the emission factors of the CA-CP program for our region rather than calculating our own so that we would be consistent with other users of the CA-CP program.

No **steam** or chilled water has been purchased by Carleton; we produce our own. Emissions from inputs (natural gas and oil) for campus boilers were entered in the stationary sources section. Chilling is done with electricity which is included in the electricity purchased section.

Stationary Sources of emissions at Carleton were from the (non-cogeneration) steam plant boilers where Carleton uses a combination of #2 oil and natural gas to make steam. Data for how much oil and natural gas was acquired for each calendar year back to 1990 form the facilities office. Carleton does not use any other stationary sources such as propane, coal or incinerated waste.

Transportation emissions include campus vehicle fleets, Carleton related plane flights by faculty, staff and students as well as emissions from commuting by faculty staff and students. Carleton did not include transportation by students to arrive at Carleton each year. Carleton is looking into how to include this data in our next inventory. Carleton also did not include bus mileage traveled by students and athletic teams in its transportation section, but again is looking at ways to acquire data for future inclusion.

Campus fleets: One set of gasoline vehicles is a collection of minivans and cars that students and faculty use for field trips and other activities. Budgetary data was acquired from Carleton's business office for the fiscal years 1995, 1999 and 2004. Gas expenditures and reimbursements were tallied for each month. The average price of gas for each of these moths was acquired from the US EPA; gas expenditures for each month were divided by the average price of gas to get data for gallons used each month which was summed for the whole year. Consumption of this campus fleet decreased from 14,007 gal in 1995 to 13,877 in 1999 and then to 11,443 in 2004. Another campus set of vehicles is the facilities and maintenance fleet including all grounds gas vehicles. Data for gasoline gallons used by facilities fleet[11] was available for the 2004 fiscal year only, (7,272 gal) 7500gal was estimated to be a past average; these values were added the other fleet to get the total gasoline fleet gallons consumed. Diesel maintenance fleet fuel was purchased at the same time from the same supplier and was also only available for the past (04-05) fiscal year (consumption was 2,166 gal), this same value was extrapolated to previous years.

Air Travel: A list of off campus study programs and the number traveling was acquired and mileage traveled was calculated for each program. This data was acquired for the academic year, 2003-2004. The distance flown to each program was determined by the distance from the major city in the country of the program to Minneapolis[12]. Distances of each program were multiplied by # of students to get a total mileage figure. Faculty and Staff: Carleton's budget office has an account that includes the majority of airline charges from faculty and staff, but not all, for fiscal years 95-96, 99-00, 04-05. A figure for average price to fly per mile of $0.25 was used; the expenditures were divided by this amount to get mileage traveled. This calculation is very rough, but we figured it would still be a decent approximation to determine miles flown by staff and faculty and better then including nothing.

Commuting: Carleton is primarily a residential campus, with the vast majority of students living on campus; it was assumed that few if any students commute to campus regularly so student commuters were not

[10] The value for full time equivalent faculty and staff was used.
[11] Waterfield oil receipts for fuel storage tanks outside of facilities.
[12] Distances calculated from website: http://www.indo.com/distance/index.html

included. Faculty and staff distances were calculated from the campus directory database using zip codes. A sum of faculty at each zip code was done and an average distance of 10.27mi from the Carleton campus was calculated[13]. We estimated an average of 210 commuting days per year (accounting for vacation and days off). We used the estimated MPG used in the CA-CP program. Zip Code data was available for 1998-1999; other years were assumed to be the same.

Carleton **Agriculture:** The amount of organic (corn gluten) fertilizer for 1999 to 2005 were gathered from Carleton's grounds staff and past values were estimated. Synthetic fertilizer data was available for 2002-2005, past values were estimated. The nitrogen percentage of synthetic fertilizer was 22-26% and 2% for Carleton's organic (corn glutton) fertilizer. Carleton has several hundred acres of arboretum, some of which is rented out to farmers; the fertilizer put on this land was not included in this inventory, only data from Carleton's grounds was included. Carleton does not have any animal agriculture.

Solid waste: Carleton contacted waste management to get a tonnage figure for Carleton's waste and paper recycling. Carleton's solid waste was determined for fiscal year 2004 and estimated for previous years. Carleton landfills all waste with no Methane (CH_4) recovery. No waste is incinerated to provide power.

Refrigeration: Refrigeration chemicals are used in very small quantities, but their GWP can be extreme, up to 2000 times greater then CO^2. Chemical amounts were acquired from Carleton facilities for fiscal year 2004 and estimated for previous years.

Offsets: Carleton composts at most of its on campus houses, this mimics that natural carbon cycle which is why composting is included as an offset. Composting tonnage was estimated for 2004 and previous years from the students who run the composting program. Carleton recently became the first college in the United States to construct and operate a utility scale wind turbine. Last year Carleton constructed a 1.65mW wind turbine producing an amount of electricity equal to 1/3 of the campus' need. However, location constraints meant that Carleton does not use the power it produces but rather sells the power to our local power company along with the emissions credits. The sale of the emissions credits means that Carleton can not count the benefits of its wind turbine as an offset to its GHG emissions.

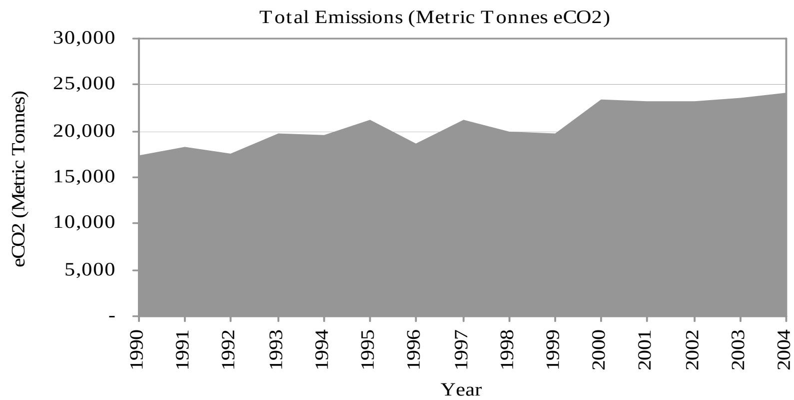
[13] Calculation was done using Carleton's address as the origin and the zip code as the destination using Mapquest.com

RESULTS OF CARLETON'S GHG INVENTORY

Carleton Completed its GHG inventory in September of 2005. Carleton conducted an inventory according to protocols outlined by the Clean Air Cool Planet eCalculator v4.0 for the year 2004. All data is presented in terms of Carbon-Dioxide Equivalent metric tons (eCO^2). Carleton's GHG Inventory was conducted by Jason Lord working as a part time facilities intern during the summer of 2005. Attempts were made to collect required back data; however, few sources were able to provide data going back more than a few years. Consequently, it was necessary to extrapolate some current data values to estimate missing past data fields. In this report, it can be assumed that historical trends are fairly accurate because data for stationary heating, cooling and electricity which account for 90% of 2004 emissions were available back to 1990. Most other emissions sources were assumed to have past values similar to their present values.

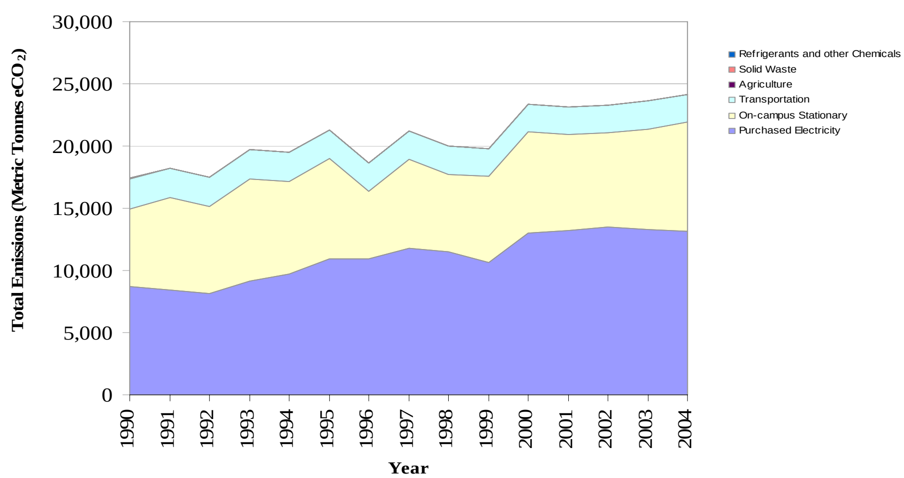
A few notable emissions sources were omitted from our inventory. Carleton rents a few plots of land in its Arboretum to farmers, these farmers might use fertilizer on the land rented from Carleton. Agricultural fertilizer data entered was only data provided by Carleton's grounds staff; it did not include Arboretum data. It is unlikely that this omission would affect results much as agriculture accounted for only 8-16 out of a total 17,000 to 24,000 metric tons of emissions. Reimbursed Airfare, airline tickets purchased for Carleton use by individuals and then reimbursed by Carleton, were also not included. This airfare may account for an additional 20-40% of airline miles flown by faculty and staff. This omission is unlikely to strongly affect results as airfare from faculty & staff represented less then 2% of total 2004 emissions. Bus travel by Carleton students, faculty and staff was also omitted for two reasons; it was not a requested input by the eCalculator v4.0, and data was not available. A lot of student travel (both academic, athletic and student activity), is done using the campus fleet of vans which was inventoried. Bus travel is unlikely to represent more then 1% of total emissions.

Historical emissions trends from 1990 to 2004 are presented in this section. The long run trend in **Graph 1** represents changes in stationary fuel usage and electricity usage. Year to year fluctuations are most likely from temperature changes. The following graph shows Carleton's total GHG emissions in metric tons (mt) of Carbon-Dioxide equivalent from 1990 to 2004. Carleton's emissions have increased from 17,400mt to 24,200mt in the past 14 years – an increase of nearly 39% from 1990!



Graph 1: [14]

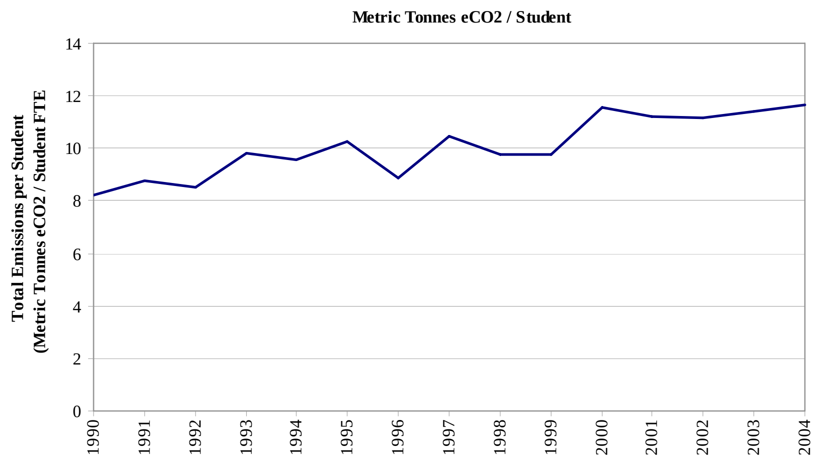
This next graph, **Graph 2**, is similar to the one above, but shows in detail the makeup of Carleton's GHG emissions year after year. Emissions other then stationary sources (heating) and electricity are relatively constant because some of the data used to calculate these emissions were only available for recent years. Emissions data for air travel, commuting (parts of transportation) solid waste, agriculture and refrigeration for years prior to 2003 are extrapolations from current data. What should be noted are the changes in stationary sources (heating) and purchased electricity during these years. Both emissions from heating and purchased electricity have increased in the past 14 years, purchased electricity substantially. We will now look at possible reasons for the increases in emissions.



Graph 2:

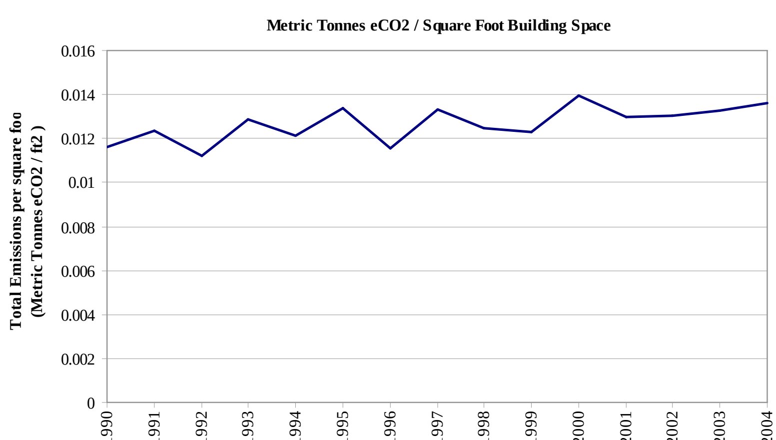
[14] **Graph 1:** Accurate emission data was collected for the 2004 year; back data for agriculture, solid waste and part of transportation is extrapolated. Heating and electrical data is accurate for all years.

During the years 1990 to 2004, the student population has remained fairly constant at Carleton. The number of students has ranged from 1,800-1,900 total students for most of the past 15 years. Emissions per student have increased by nearly __50% during this time (**Graph 3**)! Nearly every year since 1990, except for an unusually mild 1996, emissions released per student have increased. Next we will look at Carleton's campus data to see what may have caused increases in emissions.



Graph 3:

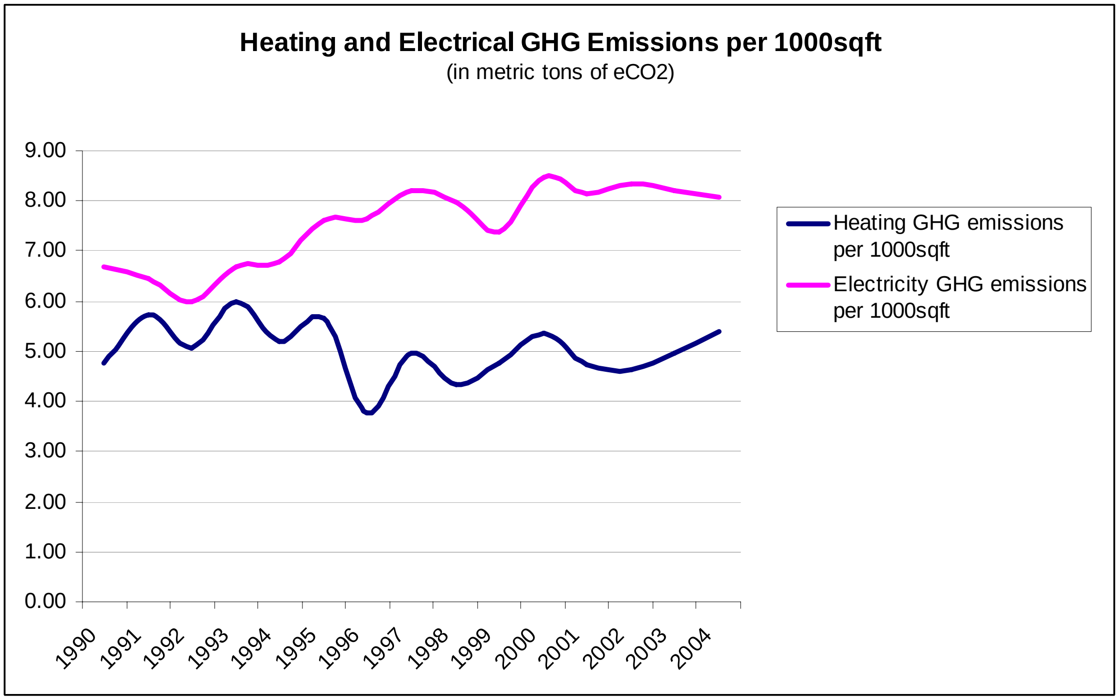
Carleton has increased its campus size (in terms of building area) substantially during this time, from a total campus building area of 1,303,532sq ft in 1990 to 1,624,616sq ft in 2004. In the immediate future, Carleton is planning to add more building space with the acquisition of the old middle school as a center for the arts. A lot of the increase in stationary sources has come from this increase in building space -- more buildings require more electricity and heat causing more GHG emissions.



Graph 4:

The previous graph (**Graph 4**) illustrates that not all of the stationary fuel and electricity emissions are caused by increases in building space. Plotting total emissions (in mt eCO^2) divided by total building area, shows that emissions at Carleton per sqft of building space have been rising from around .012 mt per sqft to .014 mt per sqft – an increase of about 17%. This increase represents an increase in demand for energy which in turn causes more GHG emissions. Increases in emissions per square foot are percentage-wise smaller than total increases in emissions, or increased emissions per student. This indicates that increases in building square footage is at least one factor causing Carleton's emissions to increase, but it is not the only factor. We will next look at stationary heat and electricity emissions per square foot in detail. **Graph 5** plots both emissions from heating and electricity per 1000 square feet of building space.

Graph 5:

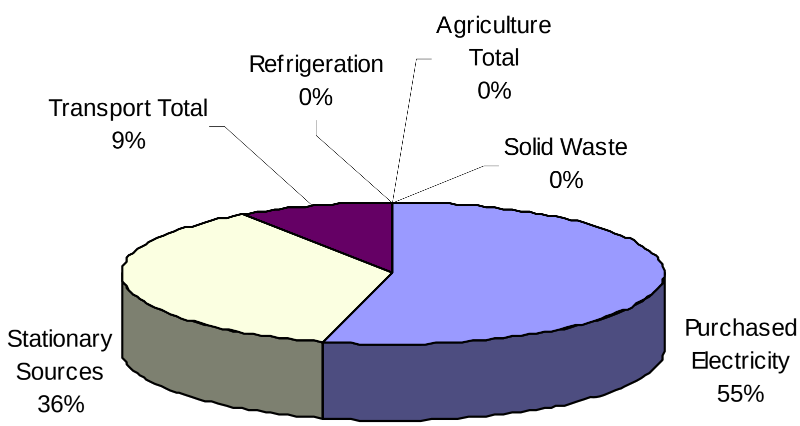


Year to year fluctuations in this graph are representative of temperature changes, but the overall trends show something very interesting. Heating emissions per square foot have remained relatively constant from 1990 to 2004, but emissions from electricity per square foot have risen substantially. Note: Emissions produced by purchased electricity and heating have remained constant per kWh/BTU during this time. How we make heat and electricity hasn't changed, this graph is entirely representative of changes in the amount of heat and electricity we use.

The average emissions from heating needs per sqft has not increased with the addition of more square footage to the campus -- meaning that the new buildings are at least as efficient for heating as the older buildings. Electrical usage increases per square foot show an increase in electricity demand. A significant jump in electricity emissions per square foot happened between 1994 and 1999. During this time there was a large increase in computers, networking, printing and other technology on campus. It is highly likely that a lot of the increase in GHG emissions from electricity was caused by increases in technology.

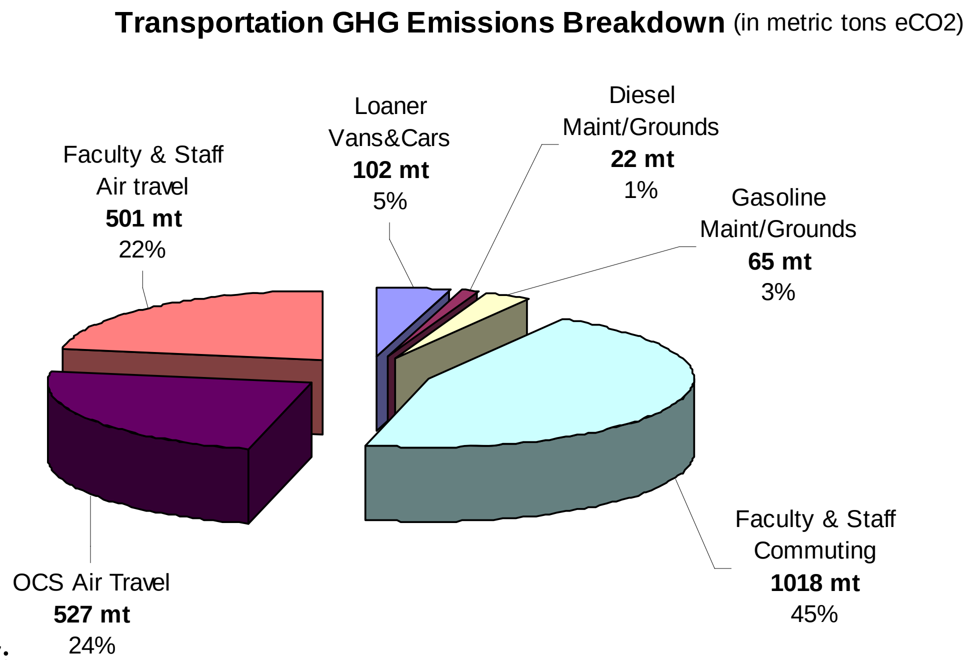
When looking at stationary sources (heating) and purchased electricity emissions, we have determined that historical increases in stationary source (heating) emissions are almost completely a result of additional buildings on campus. Emissions from purchased electricity are partly caused by the increase in buildings, but there has been a substantial increase in the demand for electricity during this time.

In this next section, we will look in detail at the current (2004) makeup of GHG emissions. Purchased electricity and stationary sources (fuel usage by the steam plant) cause nearly 90% of Carleton's total GHG emissions. Transportation is the next largest portion of Carleton's total emissions accounting for 9%. The following (**graph 6**) shows the emissions breakdown for the year 2004 (fiscal year 2004-2005).



Graph 6:

Solid waste makes up less then 1%, refrigeration chemicals makes up 0% and agricultural emissions makes up less then .1% of emissions. **Graph 7** shows transportation emissions (9% of total emissions) in detail.



Graph 7:

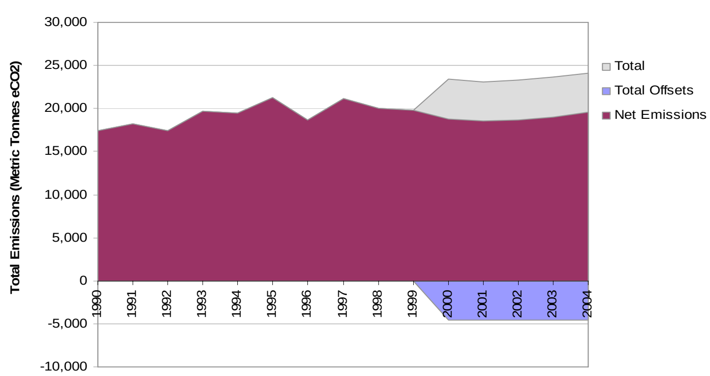
Within transportation emissions, the two main sources of emissions are faculty & staff commuting (45%) and air travel (46%). Emissions from air travel are split up into those from Off Campus Studies (OCS) and those of Carleton faculty & staff.[15] Students and faculty travel a similar amount and cause a relatively equal amount of GHG emissions. Off campus study students flew over 1,886,000 miles in 2003-2004. Per mile, air travel is one of the more efficient ways to travel, however, we should be conscious of the impacts our travel creates – over 1000 metric tons of GHG emissions. Even with Carleton students, faculty & staff flying around the world, faculty & staff commuting in their cars to Carleton creates a similar amount of GHG emissions. From calculations using zip codes, the average faculty and staff member lives 10.3 miles from campus; 650 parking permits for faculty and staff were given out last year. Calculating commuting data required some approximations, but it shows how the small actions of individuals can collectively cause a big impact, accounting for 4% of Carleton's total

[15] Note: the value for Carleton faculty & staff air travel emissions is understated by possibly 20-40%.

GHG emissions. Interestingly, Carleton's loaner vans & cars, which account for 5% of transportation emissions, used almost 20% less gas when Carleton switched from 15 passenger vans to minivans and cars.   The rest of transportation emissions come from Carleton fleets and service vehicles used by maintenance and grounds.

Carleton agriculture accounts for a very small percentage of emissions, less then .1% of total.   Carleton does not have any animal agriculture, so recorded values are only for Carleton grounds. Recently, Carleton has been using a lot of organic fertilizer which release less GHG emissions then synthetic fertilizer. Still, Carleton grounds accounts for around 8 metric tons of eCO2 emissions each year. Refrigeration chemicals have the potential to cause substantial GHG emissions from emissions of CFCs and other chemicals. Carleton's refrigeration is a closed system and does not emit any of these chemicals. Carleton waste goes to a nearby landfill that does not employ any methane recovery which causes all of Carleton's waste to release GHG emissions. Composting at Carleton helps to reduce waste and counts as an offset of GHG emissions.   Additionally, disposing of solid waste creates indirect GHG emissions from transporting the waste, these indirect emissions were not part of this study.

The only offset for Carleton emissions is Carleton's composting effects, which while good efforts, create a negligible impact in emissions reduced. A far larger offset would have been the clean power credits from Carleton's wind turbine. If Carleton were to have retained the green certificates for its wind turbine, it would have been able to reduce its GHG emissions substantially. **Graph 8** is a hypothetical graph showing the reduction in GHG emissions if Carleton included its wind turbine as an offset from year 2000 to present.



Graph 8:

CONCLUSION OF CARLETON'S GHG INVENTORY:

Carleton emitted almost 12 metric tons of Carbon Dioxide equivalent GHG emissions per student last year, an increase from 8 mt per student in 1990. Total GHG emissions have increased by 39% to 24,200mt emitted last year. Ninety percent of Carleton's GHG emissions were from stationary sources (heating) and purchased electricity. Some of the increases in heat and electricity usage are from increases in Carleton's building area from 1990 to 2004. Carleton has maintained a relatively constant heating rate per square foot, but electrical use has increased substantially. This increase is attributed to increased demand most likely from increases in technology use. Transportation accounts for 9%; all other categories of emissions did not account for much of the total emissions. Purchased electricity accounted for 55% of emissions last year; purchased electricity is also the emission source that has to potential to be most affected by changes in behavior by students, faculty and staff.

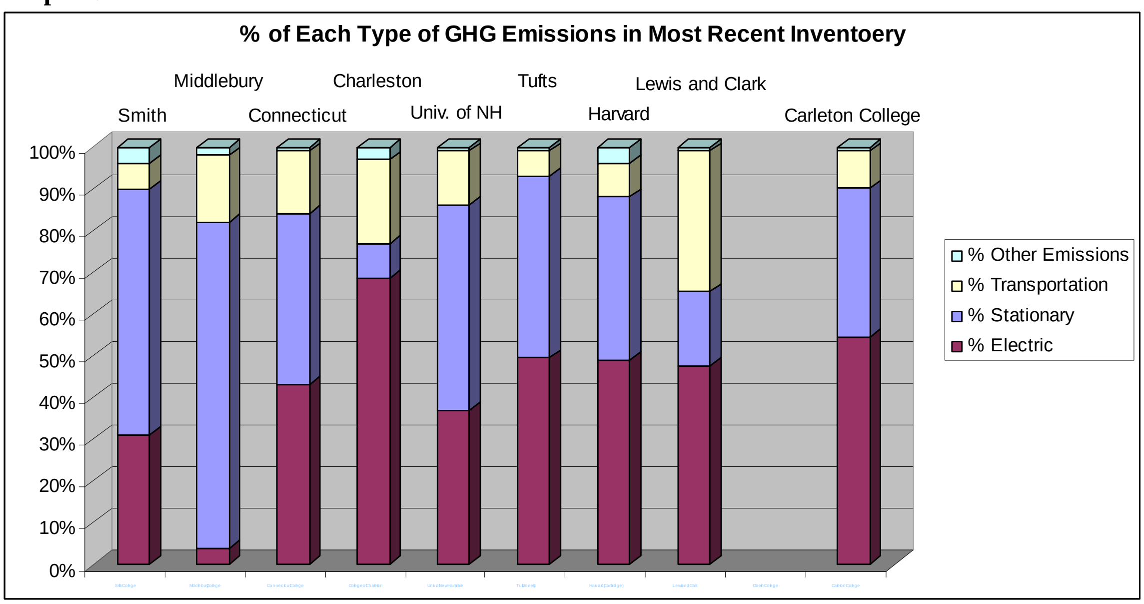
There are many opportunities for conservation to reduce the amount of purchased electricity. Classroom computers are still kept running all day and night, air-conditioning runs so vigorously in the summer that it makes many rooms uncomfortably cold. Perhaps the first step to reducing Carleton's GHG emissions is to eliminate wasteful electricity and heating use. We can all start now by doing all the little things, such as turning off electronics and lights when not needed, adapting to the season and using only what we need. Individually these efforts may seem trivial, but collectively these actions will make a difference.

There are many further steps that can be taken to conserve electricity, some of which are not economical when only the monetary cost of electricity is considered, but become economically viable when a slight value is placed on reducing GHG emissions. Carleton's Facilities office is using the data acquired in this inventory to now look at the most efficient ways to reduce our GHG emissions. Carleton is working on a proposal for a "New Carleton Energy Initiative" that looks at the costs monetarily, environmentally and socially of our energy production and consumption. This report will explore in much further detail potential conservation methods and alternative production methods for Carleton's energy. The ultimate goal of the New Carleton Energy Initiative is the creation of a defined energy policy that balances all of the costs and benefits of energy consumption and the pollution it creates here at Carleton. This GHG Inventory was the first step in working towards this goal.

CARLETON'S GHG EMISSIONS COMPARED TO OTHER SCHOOLS

The best way to compare Carleton's GHG emissions with other schools is to look at emissions per student. Conducting our inventory using the protocols in the CA-CP program allows for an accurate comparison with other schools that have used the CA-CP program. The schools presented in this comparison section have conducted GHG inventories using the CA-CP program or following similar protocols. Some of these schools are more similar to Carleton then others. In this section we see a large range in the emission breakdown of each school.

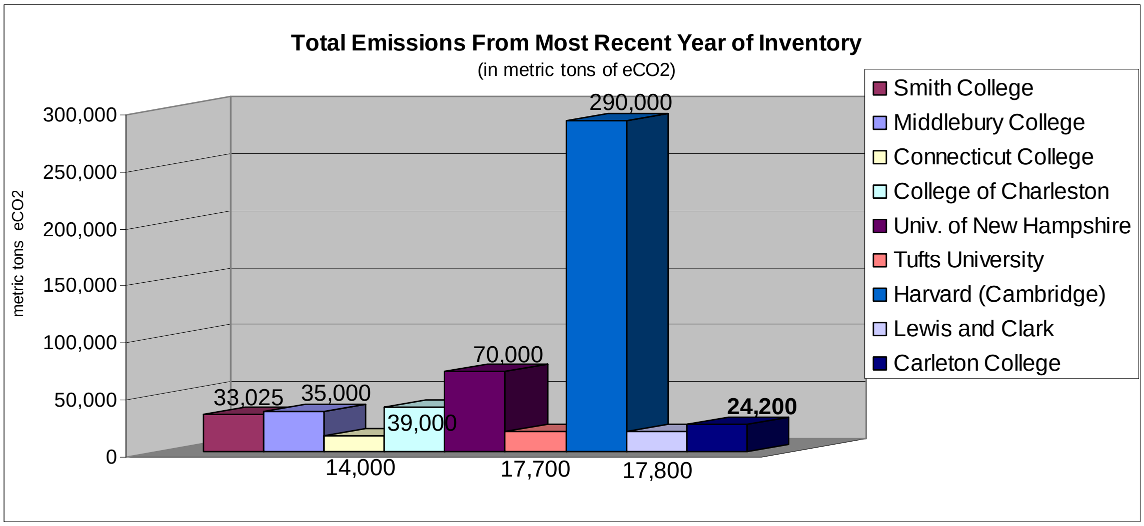
Graph 8:



Graph 8 shows the emissions breakdown of each of the schools; other emissions include those from agriculture, solid waste and refrigeration. Carleton has a similar emissions ratio as Harvard, Tufts and Connecticut College. Some schools that have more commuting students show higher percentages of transpiration emissions. Middlebury

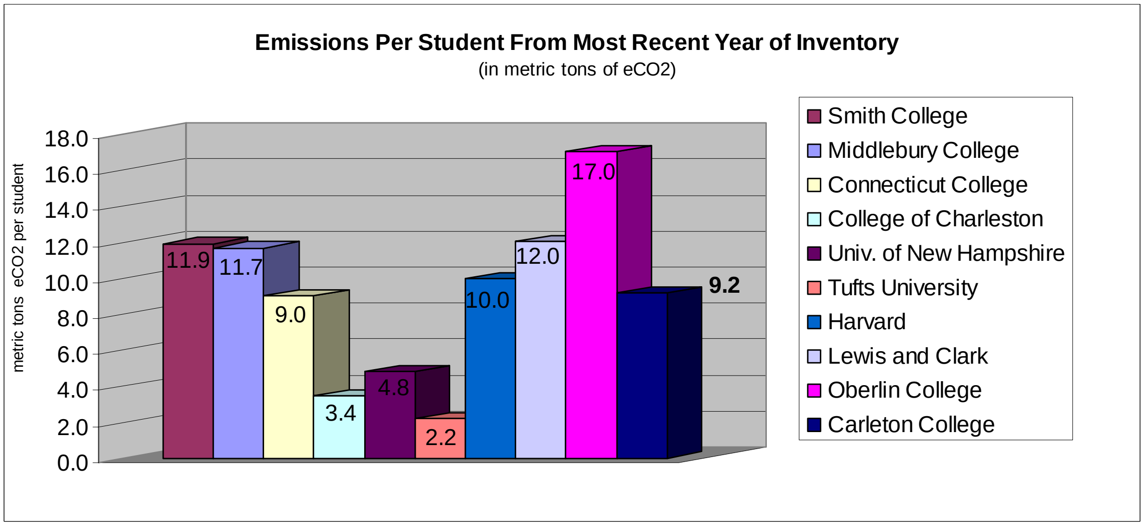
seems to be an outlier with its extremely low emission from purchased electricity. Lewis and Clark have a percentage of emissions from transpiration higher then any other school.

Graph 9:



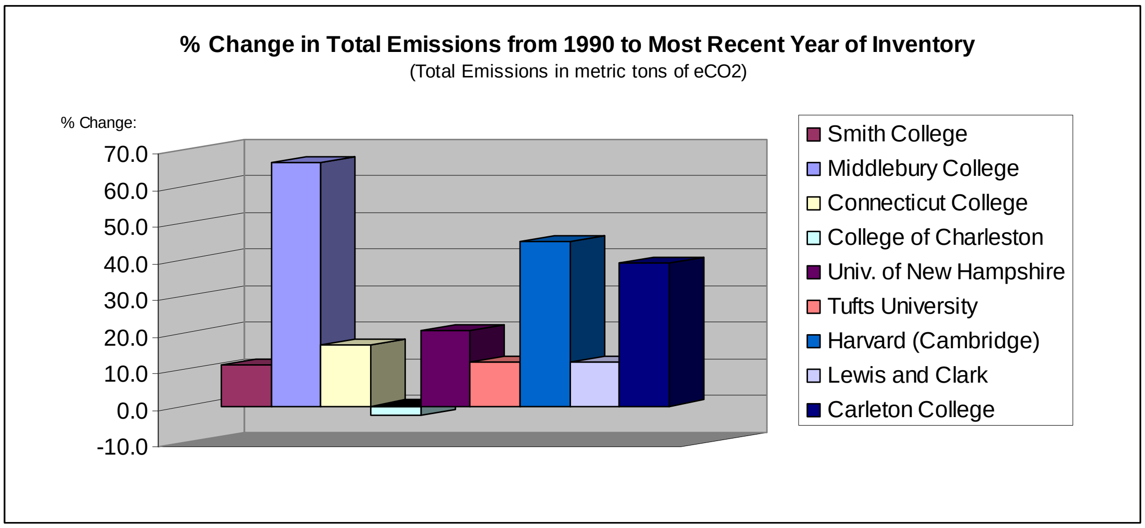
Graph 9 illustrates total emissions per school, the one school that has the highest emission was Harvard (Cambridge campus), with 290,000 metric tons emitted in the most recent year of their survey. Carleton emitted 24,200 metric tons of GHG. It is not a fair comparison to say we emit ten times less then Harvard, Harvard has nearly ten times more students then Carleton. The following graph (**Graph 10**) looks at GHG emissions per student for each different school.

Graph 10:



Carleton's emissions per student are similar to the average emissions per student of 9.2 metric tons of CO^2 emissions per student per year. Carleton emits less then Smith, Middlebury, Harvard, Lewis & Clark and Oberlin -- all schools that are similar to Carleton. Emissions per student are almost identical to those from Connecticut College. The three colleges with lower emissions per student may have more students living off campus, and/or more temperate climates. In the comparisons so far, Carleton is fairly competitive both in total and per student GHG emissions. The next graph (**Graph 11**) shows the percentage that emissions have changed since 1990.

Graph 11:



Carleton's GHG emissions have increased by nearly 40% since 1990, only Middlebury[16] and Harvard recorded larger increases in GHG emissions during this time. Every school except for the College of Charleston increased GHG emissions since 1990.

Carleton is right in the middle of the pack compared with other schools, when considering Carleton's climate of hot summers and cold winters we compare even more favorably to other schools. However, there is a **lot** of work that can be done. Carleton's emissions have increased faster then most other schools. The Kyoto protocol calls for a 7% reduction in emissions for the United States. If Carleton were to meet this protocol, it would have to reduce emissions by nearly 47% from current levels by 2012.

[16] The most recent emissions data for Middlebury was 2002.

Several other schools are pursuing innovate energy policies to reduce their GHG emissions. Middlebury has embarked on a Carbon neutrality policy that is aiming to reduce total emissions to **Zero, calling for an 8% reduction from 1990 levels by 2012.**[17] This past year, Middlebury received the 2005 climate champion award for their leadership in reducing their emissions. Lewis and Clark became the first college to adopt the Kyoto protocol when their students enacted a self imposed a tax to pay for emissions credits to become Kyoto compliant for one year. Carleton took a good step forward with the construction of the wind turbine, but we need do more. The next step is for Carleton students, faculty and administration to develop a GHG reduction plan. Carleton can be a model for other colleges, communities and individuals to show how we can take action to make a cleaner and cooler world.

[17] http://community.middlebury.edu/~cneutral/