Connecticut College

Greenhouse Gas Emissions Inventory
1990-2002

A collaborative project of the Goodwin-Niering Center for Conservation Biology and Environmental Studies and Clean Air-Cool Planet

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Introduction

Climate Change Overview

Since the industrial revolution of the 18th century, human activity has been altering the composition of the earth's atmosphere by increasing its concentrations of greenhouse gases. Greenhouse gases such as carbon dioxide or methane absorb the solar radiation reflected by the earth, retaining heat to warm the planet's surface and lower atmosphere. Because the atmospheric concentrations of carbon dioxide have increased by 30%, methane by 50%, and nitrous oxide by 15% since the revolution, the heat-trapping capability of the atmosphere has been greatly enhanced[1].

Although a large amount of uncertainty surrounds the issue of global climate change, there is a preponderance of evidence suggesting that humans are responsible for the increase in global temperature resulting from augmented levels of greenhouse gases in the atmosphere. The average global surface temperature has risen about 1 degree Fahrenheit in the past century, with the warmest years all occurring in the last 15 years of the 20th century[2]. Additional evidence of this climate alteration includes decreased snow cover in the Northern hemisphere, melting glaciers, and the rise of global sea levels by 4-8 inches over the past century[1]. Other potential effects include increased precipitation, decreased soil moisture in certain locations, and frequent, intense rainstorms. The uncertainty lies in the fact that other factors may be contributing to this temperature increase such as natural climatic systems, the emissions of sulfate aerosols, or fluctuations in the sun's energy. However, the IPCC states in its Third Assessment Report (2001) that, "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

Human activities which may lead to global warming include the burning of fossil fuels, the combustion of solid waste materials, the decomposition of livestock waste, deforestation, and population growth. These activities exacerbate the climatic effects of certain naturally occurring greenhouse gases, namely carbon dioxide, nitrous oxide, methane, and halocarbons. Each of these gases differs in its ability to absorb heat in the atmosphere, so estimates of greenhouse gas emissions such as those in this inventory are usually presented in metric tons of carbon dioxide equivalents which weights each gas by its Global Warming Potential (GWP). A gas's GWP is its radiative forcing which allows it to trap energy in varying degrees. The following table illustrating the GWP's of the major anthropogenic greenhouse gases for a quick comparison of their effects on the atmosphere.

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[1] Global Warming- Climate, US EPA, 2000
http://yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html
[2] Global Warming- Climate Uncertainties, US EPA, 2000
http://yosemite.epa.gov/oar/globalwarming.nsf/content/ClimateUncertainties.html

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 1: The Global Warming Potentials and atmospheric lifetimes of the major anthropogenic greenhouse gases[3].

International efforts to mitigate the potential ecological impacts of the anthropogenic greenhouse effect began with the creation of the United Nations Framework Convention on Climate Change (UNFCC) in 1992, an agreement between 162 countries worldwide to band together with the goal of stabilizing greenhouse gas concentrations to prevent the dangerous effects of human interference with climate[4]. In 1997, the convention drafted the Kyoto Protocol which contains specific targets and timetables for countries to reduce their emissions by a certain percentage of 1990 levels. In order for these commitments to become legally forceful, it will require the ratification of at least 55 industrialized (Annex I) nations that contributed at least 55 % of the total carbon dioxide emissions from 1990[5]. Despite US membership in the UNFCC and its previous signature of the Protocol, the specified emissions reductions were not ratified by Congress. Although the US is the largest contributor of greenhouse gases worldwide, the Kyoto Protocol may still go into force despite the nation's decision to back out of the agreement as it has been signed by many other important contributors such as China and the European Union. In addition, many smaller institutions within the United States are attempting to meet or beat the guidelines of the Kyoto Protocol in order to reduce anthropogenic greenhouse gas concentrations on a microcosmic level. Completing an emissions inventory like this one is the first step in the process to meet this international goal.

Why Conduct An Inventory

The purpose of conducting an inventory of the anthropogenic greenhouse gas emissions generated by Connecticut College is first to uncover the various origins of these emissions, then to investigate possible reduction methods in order to diminish the campus's contribution to the potentially devastating effects of global warming. It is also hoped that this inventory will increase awareness within an already environmentally

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[3] Inventory of US Greenhouse Gas Emissions and Sinks: 1990-1998, US EPA, 2000
http://www.epa.gov/globalwarming/publications/emissions/us2000/executive_summary.pdf
[4] A Beginner's Guide to The UN Framework Convention, UNFCC, 1994
http://unfccc.int/resource/beginner.html
[5] The Convention and the Kyoto Protocol, UNFCC, 2003
http://unfccc.int/resource/convkp.html

conscious campus community of how our daily practices are contributing to a worldwide phenomenon which may drastically change the future state of our natural environment.

Methodology of Inventory

The methods used for this inventory were directly based upon guidelines established by the Intergovernmental Panel on Climate Change (IPCC) for the formulation of nation-wide greenhouse gas inventories. The non-profit organization Clean Air-Cool Planet adapted these methods of the IPCC specifically for use at a college or university. As such, the findings are reported in terms of the quantity and sources of emissions in metric tonnes of carbon dioxide equivalents according to each gas's Global Warming Potential in order to demonstrate their relative contribution to climate change. Explanations and references for most calculations appear in the appendix to this report. It should also be noted that the emissions calculations are reported in terms of fiscal years as opposed to calendar years. For example, emissions for the year 1995 include those beginning in July 1994- June 1995.

Several potential sources of greenhouse gas emissions were not included in this inventory as its scope was limited to those emissions which can be directly influenced by Connecticut College and its associated energy policies. For example, the college is able to control the types of fuels it utilizes to produce heat. However, it cannot control the delivery of packages by UPS to the campus which also generates emissions of carbon dioxide. However, because this inventory uses the protocol established by the IPCC, it provides a more than adequate basis on which to formulate possible energy policies at Connecticut College in order to reduce emissions.

Carbon dioxide emissions from biogenic sources were not included in this inventory in accordance with IPCC methodology. Biogenic sources of CO_2 include the combustion of biomass from wood materials, for example, in which carbon was removed from the atmosphere through photosynthesis into the wood, yet will eventually be replaced through the natural biogeochemical cycle of carbon. This inventory is restricted to anthropogenic sources of emissions because it is these emissions generated by humans that have the potential to alter the earth's climate and environment by disrupting the natural balance of the carbon cycle.

Connecticut College Greenhouse Gas Emissions

Connecticut College is a private liberal arts school with a population of about 1800 students who come from 43 states and 56 countries. The majority of students live on the 750-acre campus which is managed as an arboretum. The total emissions generated by campus-wide operations at Connecticut College can be divided into the following three sectors: energy and transportation, waste, and refrigeration.

Total Direct Emissions

Over the past decade, the direct emissions of carbon dioxide and other greenhouse gases including nitrous oxide, methane, and halocarbons at Connecticut College has increased by about 25%, from 11,851 metric tonnes of CO_2 in 1990 to the emission of 14,834 metric tonnes of CO_2 in 2002 (Figure 1). The majority of these emissions are a result of the amount of electricity purchased by the college which accounts for about 40% of emissions yearly, as well as on-campus stationary sources of energy which account for about 45% yearly. These on-campus stationary sources are comprised of the oils, natural gas, and propane used to run the campus's heat-generating boilers. Commuting faculty/staff members, commuting students, the campus-owned fleet of vehicles, athletic team travel, and the disposal of solid waste account for the remaining emissions sources.

The major reasons surrounding the 25% increase in direct emissions since 1990 include an increase in the electrical energy demanded due to the installation of cable TV access in the dormitories in 1991, a large increase in the average round trip traveled by commuting faculty and staff members, as well as the completion of several new buildings including the Olin Science Center in 1995, the Lott Natatorium at the Athletic Center, and an addition to Hale Laboratory including a chiller. The Crozier-Williams Campus Center and four North Complex residence halls were also renovated with air conditioning and consequently increased energy demands throughout the 90's[6]. Other significant contributors are the periodic increases in on-campus stationary sources which are used for heating, particularly in 1994 which was the coldest winter of the decade[7]. This factor is largely weather-dependent, however.

[6] Personal communication. Connecticut College Media Services, phone: 860-439-2693
[7] Connecticut Climate Yearly Summaries, Northeast Regional Climate Center, 2002 http://www.nrcc.cornell.edu/climate/climate_summary.html

Total direct emissions do appear to be decreasing in recent years. This decrease, which is attributable to the college's conversion to renewable energy sources, is likely to continue as a greater percentage of purchased electricity is offset by the production of clean sources such as wind power.

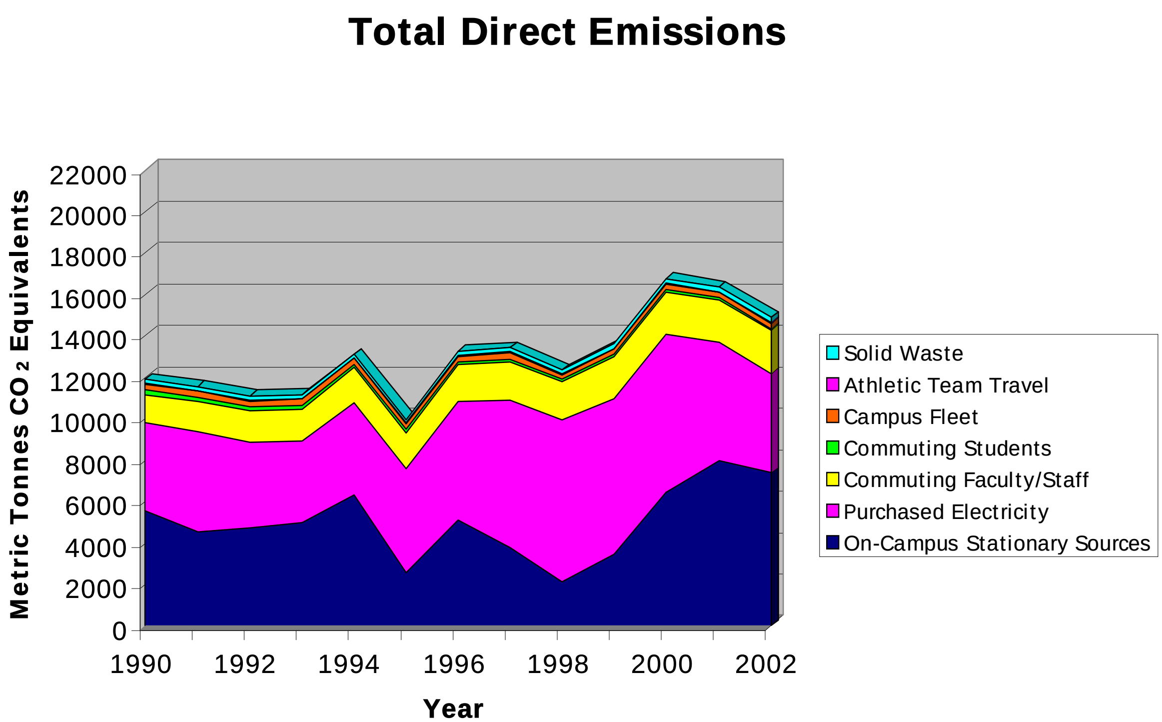

Figure 1: Total direct emissions from 1990-2002 in metric tonnes of CO_2 equivalents.

Total Direct & Upstream Emissions

In order to conduct a more comprehensive investigation of the emissions generated by the campus, it is necessary account for upstream emissions or those emissions generated by the recovery and production of fuels utilized by campus operations. These emissions do not emerge from the smokestack on campus but were instead released by the generation, refinement, transport, and storage of the fuels consumed by the college. These upstream emissions calculations were generated based upon the U.S. Department of Energy Report *The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation*[8]. In order to meet the guidelines of the US EPA and the IPCC, Connecticut College's emissions have been reported both with and without the upstream emissions.

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[8] *The Greenhouse Gases, Regulated Emissions, and Energy Use In Transportation* (GREET) Model 1.5a, Argonne National Laboratory, US Department of Energy, Michael Wang, mqwang@anl.gov http://www.transportation.anl.gov:80/ttrdc/greet/index.html

Connecticut College's total greenhouse gas emissions increase by 19.59% when upstream emissions are taken into account (Figure 2). This is a result of the use of highly refined fuels such as gasoline.

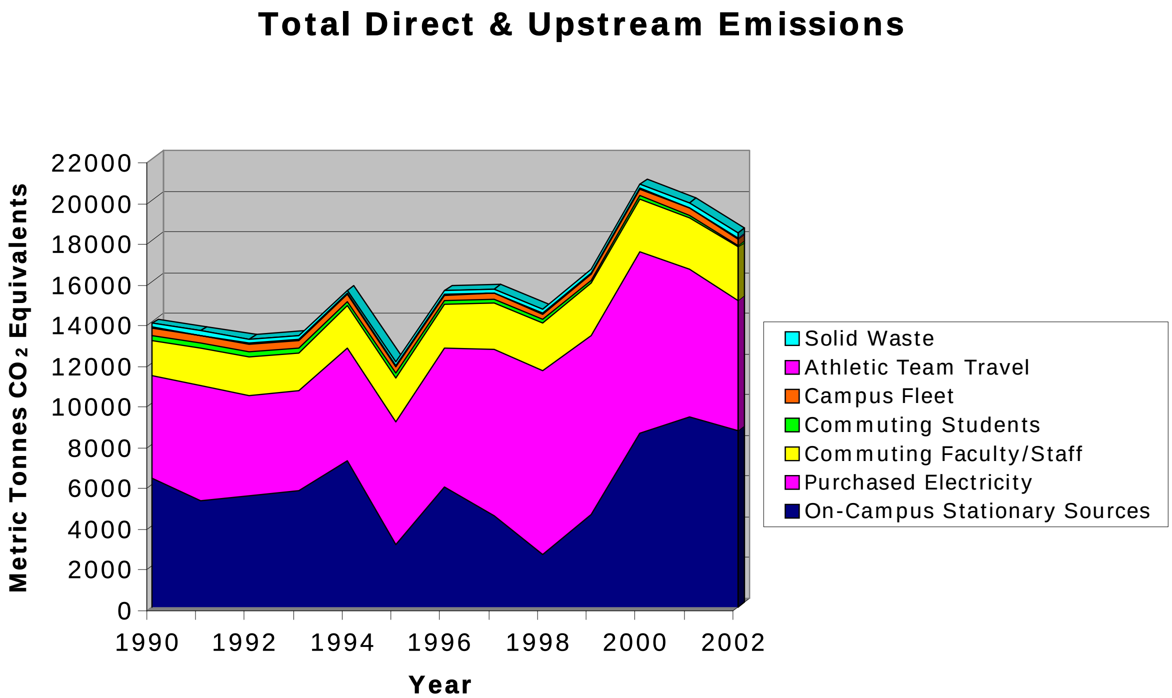

Figure 2: Total direct and upstream emissions from 1990-2002 in metric tonnes of CO_2 equivalents.

Emissions & Energy Use Per Student

The population of undergraduate students attending Connecticut College has remained fairly constant at around 1,600 students over the past ten years (Figure 3). However, the student body size increased to 1,917 in 2002 and is currently at 1,875 students in 2003[9]. This increasing population trend of recent years is likely to augment the campus's impact on global climate change in the future.

Although the student body population has increased only slightly throughout the 90's, the energy use per student has increased by 55.65% since 1990 (Figure 4). The emissions per student have also increased by 38.03% since 1990, up from 7.1 to 9 metric tonnes of CO_2 equivalents per student per year (Figure 5).

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[9] Personal communication. Patricia Deguire, Connecticut College Office of Records and Registration, phone: 860-439-2067

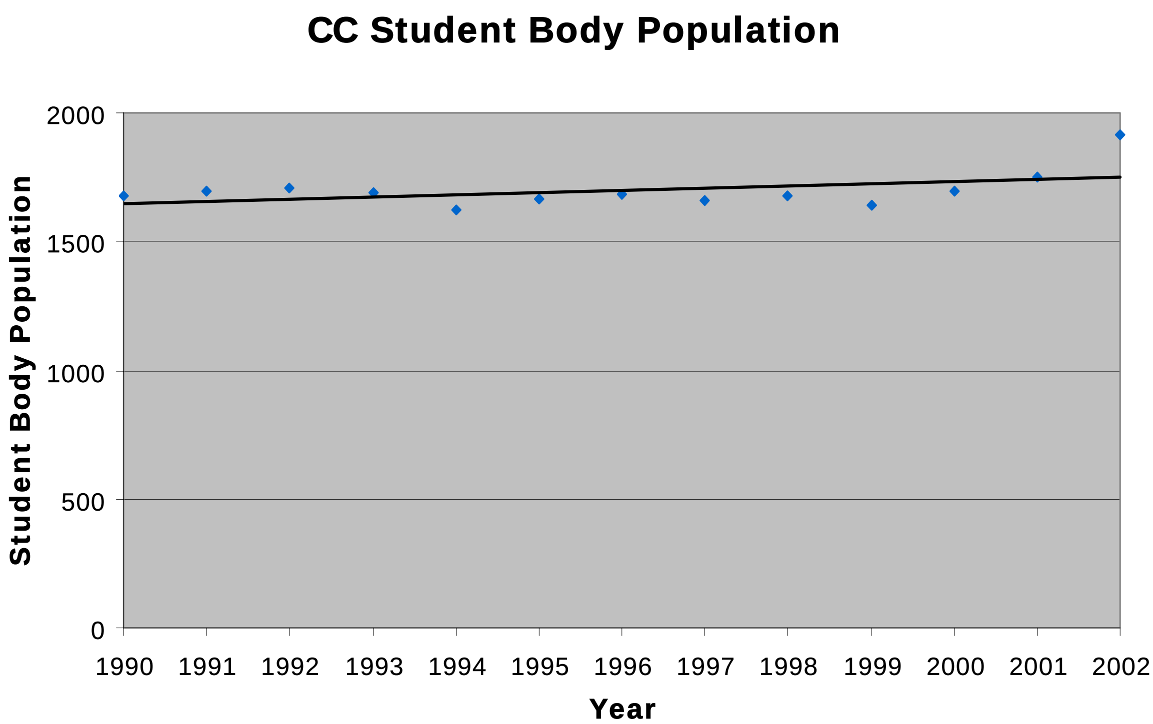

Figure 3: Connecticut College undergraduate student body population from 1990-2002 shown by a best-fit linear regression line.

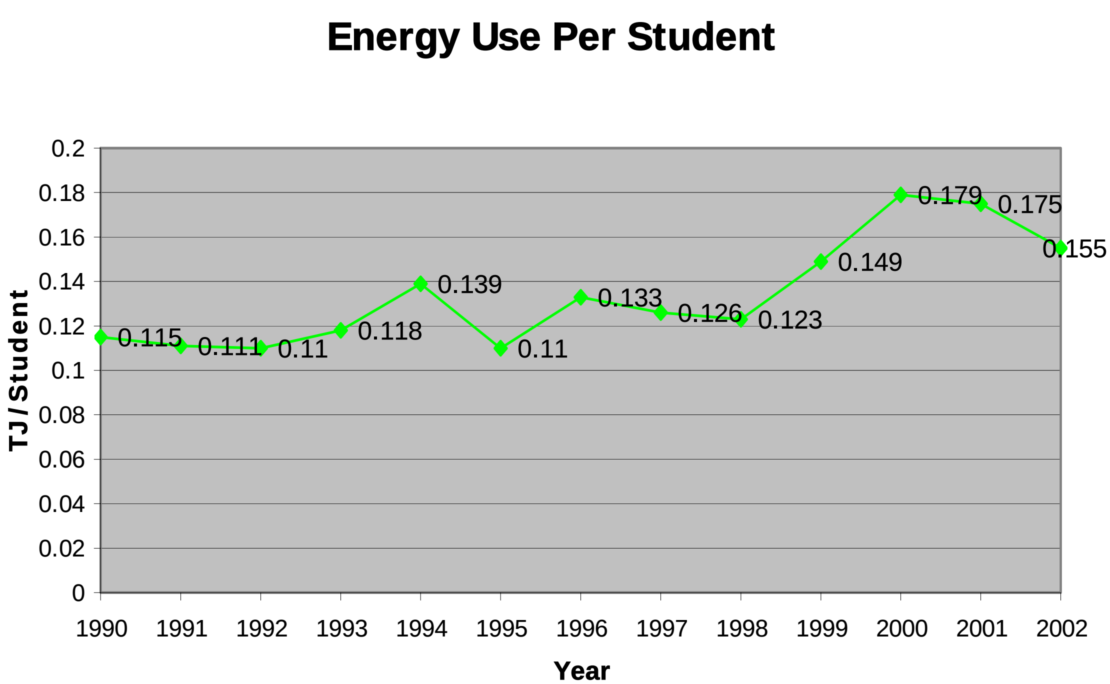

Figure 4: Energy use per student in terajoules/student/year from 1990-2002.

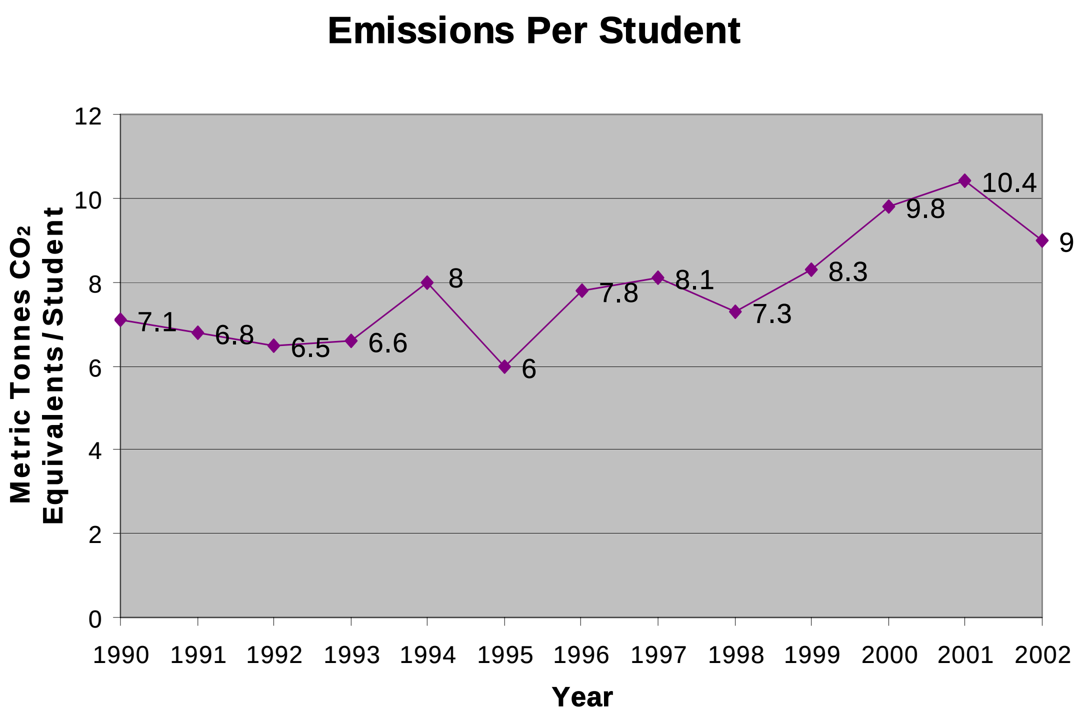

Figure 5: Emissions per student in metric tonnes CO_2 equivalents/student/year from 1990-2002.

The calculation of emissions per student provides a useful tool to compare Connecticut College students' impact upon climate change to students at other universities as it is difficult to compare total emissions due to differences in student body populations, campus infrastructures, and the methodology of inventories. The yearly emissions per CC student in both 1990 and 1998 exceed those of students at the University of New Hampshire according to their Office of Sustainability Programs' Greenhouse Gas Emissions Inventory (Table 1). However, CC students' emissions are slightly lower than those students at Tufts University according to a report of the Tufts University Climate Initiative. Connecticut College and Tufts University students also demonstrate an increase in emissions/student over time, while the University of New Hampshire exhibits a net decrease since 1990.

School	Emissions/Student 1990 (MTCDE)	Emissions/Student 1998 (MTCDE)
University of New Hampshire	5.34	5.25
Tufts University	7.52	7.99
Connecticut College	7.07	7.34

Table 2: Comparison of the emissions/student among UNH, Tufts, and Connecticut College for 1990 and 1998.

Emissions By Source

The sources of emissions generated by Connecticut College can be divided into the following four major categories: on-campus stationary sources, electricity, transportation, and solid waste. The graph below provides a representation of the typical breakdown of sources at the college for FY 2000 (Figure 6). These percentages have remained fairly constant since 1990.

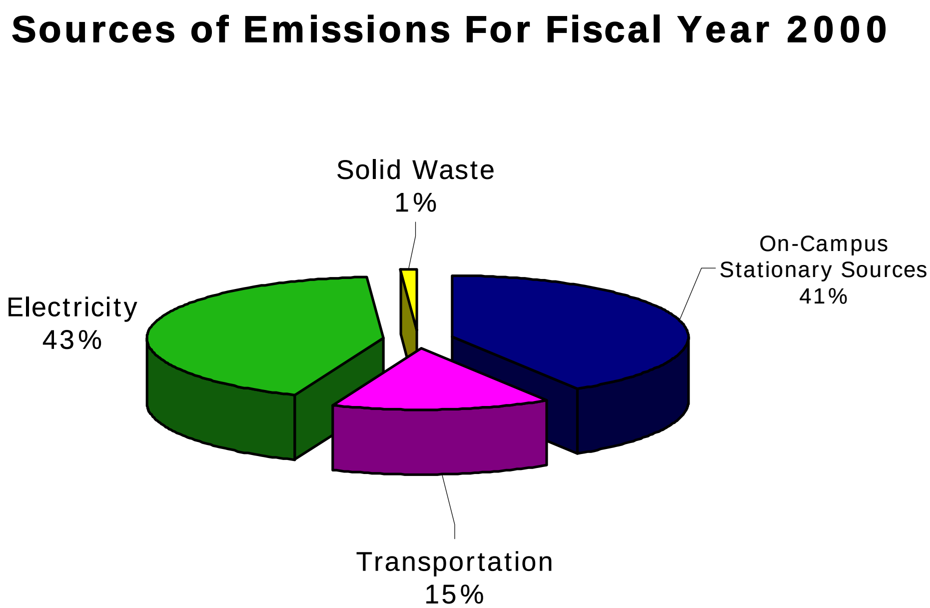

Figure 6: Sources of Connecticut College's emissions, by percent, for Fiscal Year 2000. Total emissions are equal to 20,740 metric tonnes of CO_2 equivalents.

Sector I: Energy and Transportation

Energy Sources

The combustion of fossil fuels such as oil and gas releases large amounts of carbon dioxide along with smaller amounts of methane and nitrous oxide. As shown below, 80% of Connecticut College's energy is derived from these high-emission sources.

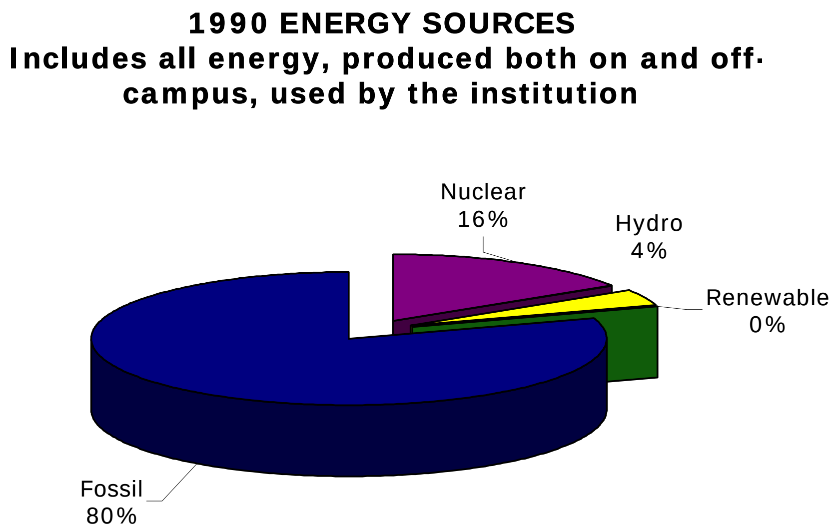

Figure 7: Connecticut College's overall breakdown of energy sources for Fiscal Year 1990.

On-Campus Stationary Sources

The powerhouse at Connecticut College contains several boilers which are ignited by propane and run on various fuels including #6 fuel oil, distillate oil, and natural gas- the combination of which is dependent on the prices during specific years[10]. For example, in the year 2000, no residual oil was used and the boilers ran on 101,005 MMBtus of natural gas. Other years #6 oil is the dominant source, and very little natural gas is utilized. These boilers generate steam which is then distributed across campus and used primarily for heating the campus's buildings as well as for hot water at showers and for cooking in the dining halls.

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[10] Personal communication. Peter Horgan, Connecticut College Engineering Systems Manager, phone: 860-439-2294

The long-term trend in emissions resulting from on-campus stationary sources is an increase by 37.45% since 1990. However, the usage of fuels for heating is variable as it is highly dependent upon the weather.

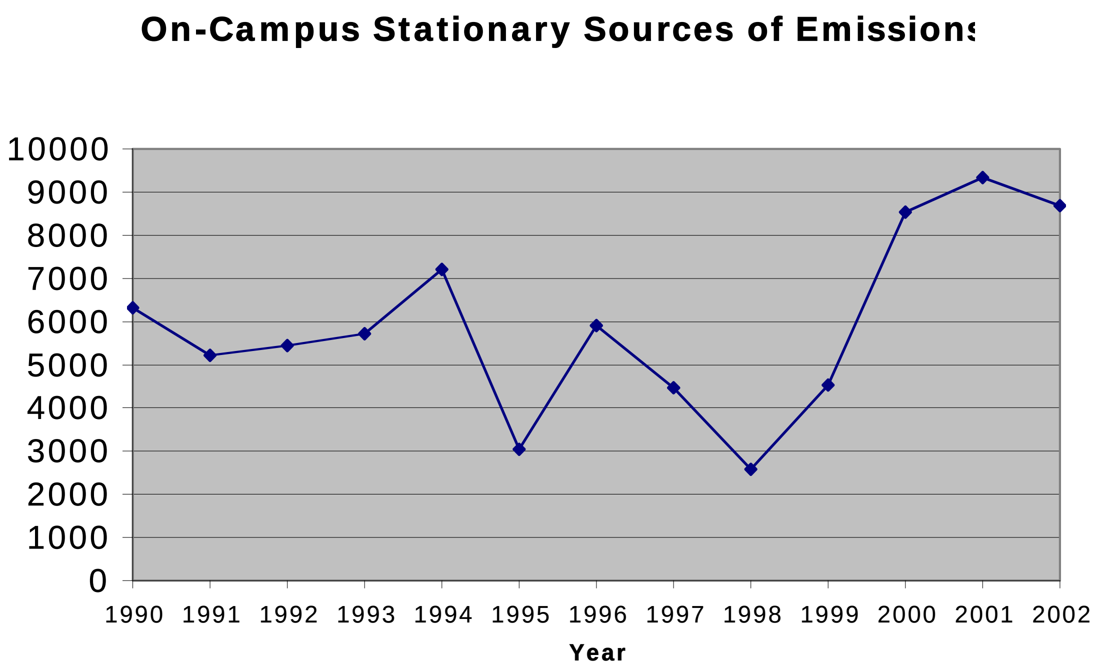

Figure 8: Emissions generated by on-campus stationary sources including natural gas, distillate oil, residual oil, #6 fuel oil, and propane in metric tonnes of CO_2 equivalents from 1990-2002.

Electricity

Connecticut College purchases all of its electricity used for lighting, cooking, etc. from The Connecticut Light and Power Company (CL&P) which is a part of the Northeast Utilities System. Since the deregulation of the electric industry in Connecticut in 2000, which forced all company's to rid their power generation assets, CL&P has taken on the responsibility of delivering and distributing energy from the New England power grid to its clients[11]. The power grid's supply is now under the control of the nonprofit organization Independent System Operator-New England (ISO-NE) which manages the grid and ensures its stability. This organization also monitors the types of energy which are utilized to generate this electricity which include hydroelectric, distillate oil, nuclear,

[11] Company Information, Connecticut Light and Power, 2003 http://www.cl-p.com/companyinfo/indexcompanyinfo.asp

coal, natural gas, residual oil, renewable sources, and imports from Canada. The emissions generated by the purchase of electricity were estimated using the number of kWh purchased per year by the college along with the percentages of each fuel type used to produce the electricity as reported by the ISO-NE's annual reports (Figure 9)[12].

The emissions generated by the purchase of electricity have increased by 21.29% since 1990. However, emissions are moving in a downward trend due to the college's recent purchase of renewable energy certificates (Figure 10).

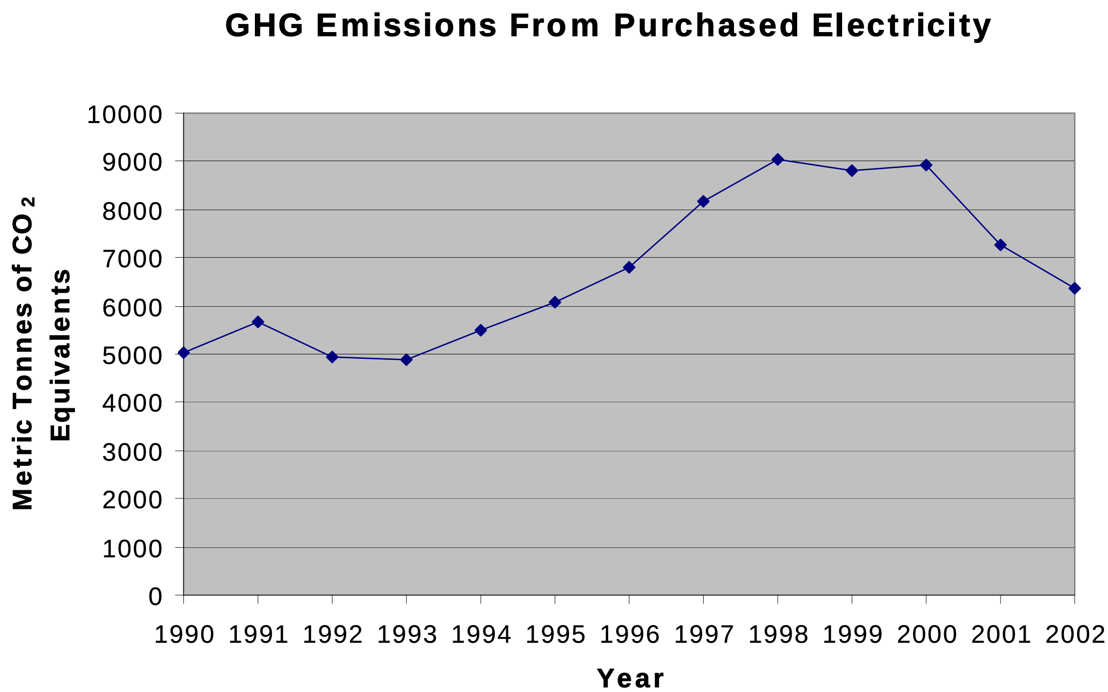

Figure 9: Greenhouse gas emissions resulting from electricity purchased from 1990 to 2002 in metric tones of CO_2 equivalents.

[12] New England Power Pool Annual Reports, 1990-2002. ISO-NE http://www.iso-ne.com/smd/operations_reports/

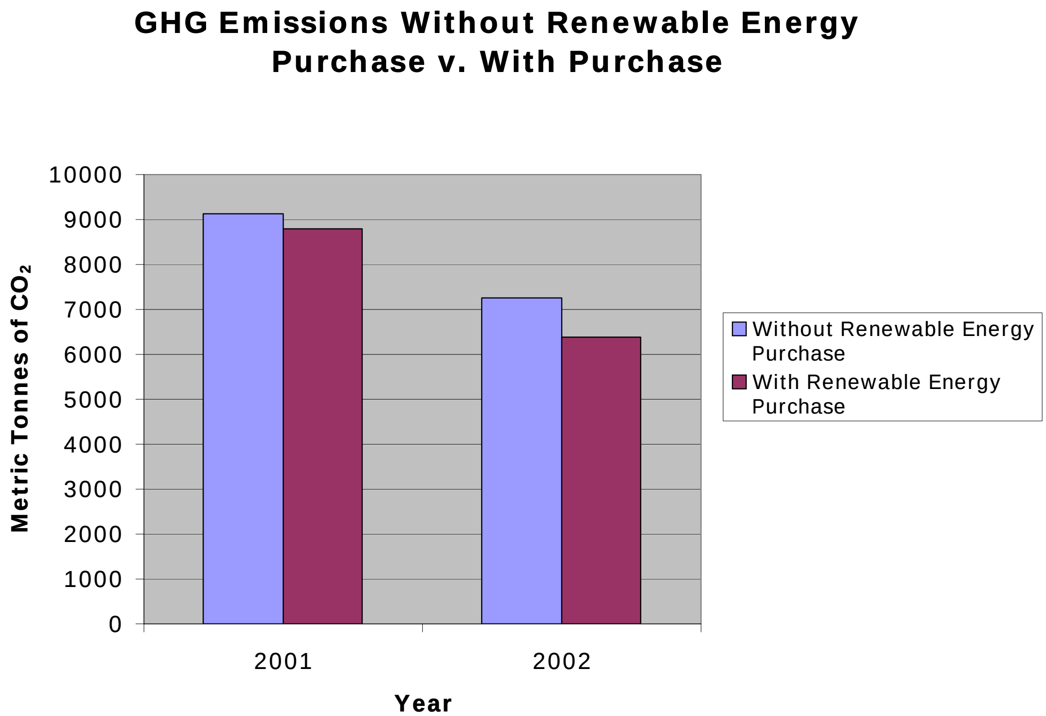

Figure 10: Comparison of the greenhouse gas emissions generated by the college taking into consideration the renewable energy offsets purchased versus the projected emissions without the purchase in metric tonnes of CO_2 equivalents per year for 2001 and 2002.

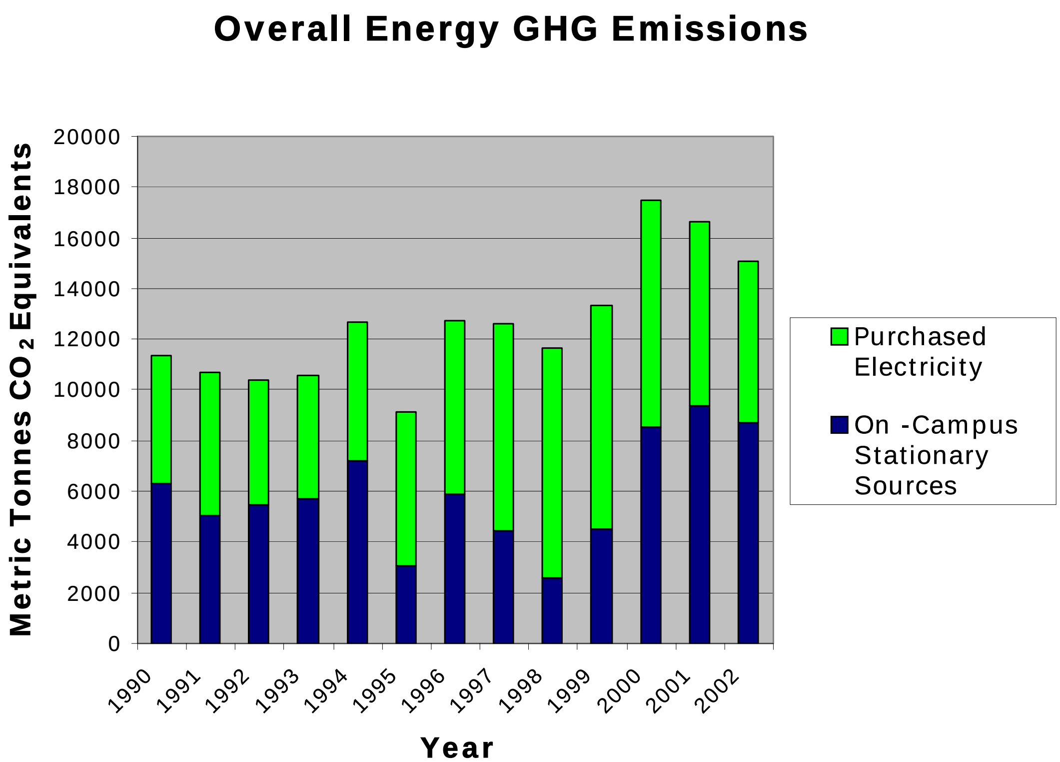

Figure 11: The overall greenhouse gas emissions generated by the use of energy at Connecticut College from 1990-2002 in metric tonnes of CO_2 equivalents.

Campus Fleet

Another source of greenhouse gas emissions on campus is the Connecticut College Fleet or "Motor Pool" which accounts for about 2% of total emissions yearly. The fleet is comprised of the following vehicles which are fueled by both diesel and gasoline at on-campus pumps: 23 minivans, 8 pick-up trucks, 6 small, service Mitsubishis, 3 box trucks, 5 full size vans, 2 cars, 1 trash truck, as well as several tractors, loaders, and lawn mowers. The amount of emissions generated by these vehicles was determined from the number of gallons of gasoline and diesel fuel purchased from Mystic Oil Company and McCarthy Heating Oil Service, respectively, found on monthly bills from each company since 1990[13]. Overall, emissions have decreased since 1990 by 14.97%, which is likely attributable to the purchase of several small Mitsubishis to replace larger vehicles that has resulted in decreased gasoline usage (Figure 12).

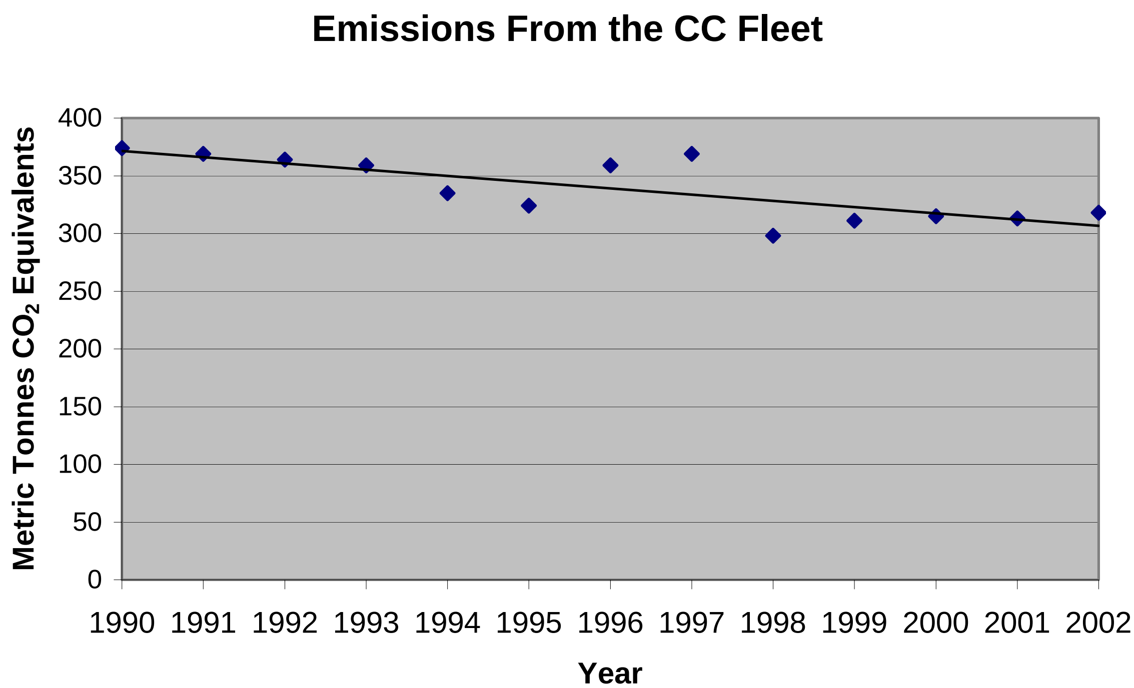

Figure 12: Emissions resulting from the Connecticut College fleet of vehicles in metric tonnes of CO_2 equivalents from 1990-2002 shown with a best-fit linear trend line.

Commuting Students

The greenhouse gas emissions generated by commuting students was calculated by approximating the gallons of fuel burned from trips to campus per year based on the number of days and the number of miles traveled. This calculation was limited to summer school student commuters and to those students who live off-campus in the New London area.

Greenhouse gas emissions generated by student commuters have decreased by 60.22% since 1990 (Figure 13). This is probably due to a decrease in the number of fall/spring commuting students since 1990 by 70%. The average distance traveled by student commuters has remained constant over time (Appendix A1).

Commuting Faculty/Staff

The emissions generated by commuting faculty/staff have increased substantially over time. The number of miles traveled and thus the average amount of fuel burned for the

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[13] Personal communication. Elaine Miller, Connecticut College Physical Plant Accounts Payable, phone: 860-439-2263

staff was calculated using the number of days worked per year based on average vacation times, the number of miles traveled from home calculated using Mapquest.com, and EPA national averages for automobile fuel efficiencies. The same method was employed to calculate these data for the faculty. However instead of using average vacation days, the number of travel days/year for faculty members was calculated by issuing a survey which demonstrated an average of 212 travel days/year (Appendix A2). The tremendous increase in emissions is largely due to the fact that the average distance traveled by faculty members has increased from 31.85 miles/round trip in 1990 to 42.39 miles/round trip in 2002. The staff has also been moving farther away from New London, thus making longer commutes with the average round trip increasing from 19.29 miles in 1990 to 23.36 miles in 2002. The emissions from commuting faculty/staff amounted to 12.42% of the college's total greenhouse gas emissions in 1990, and 14.26% in 2002.

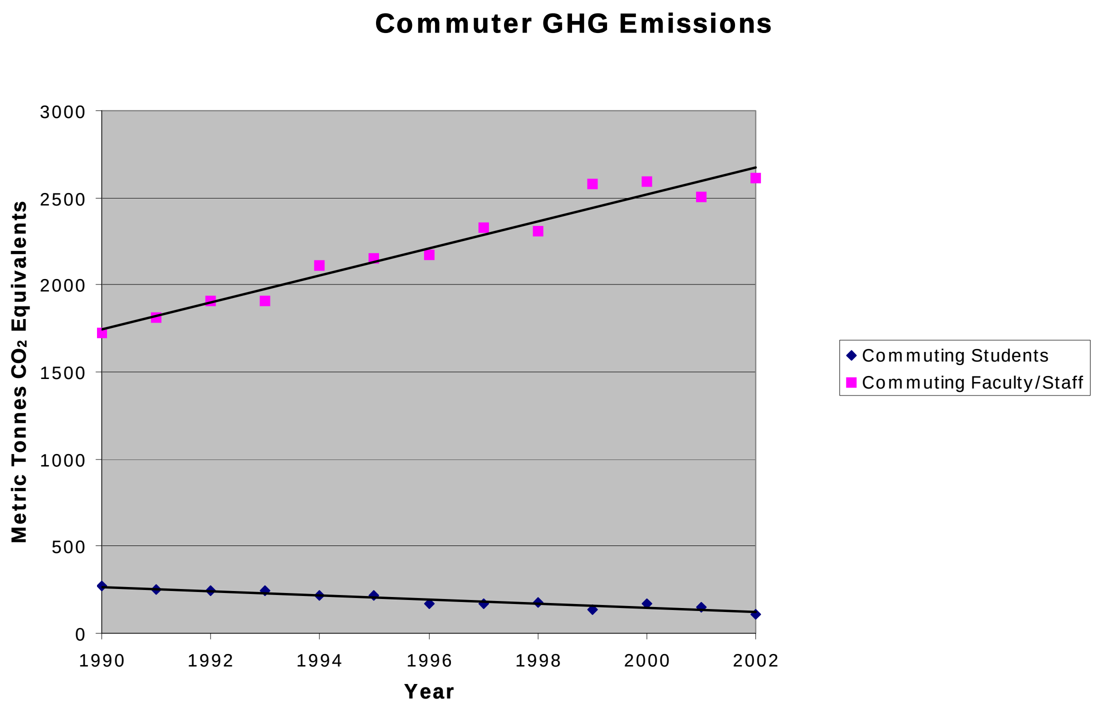

Figure 13: Emissions generated by commuting faculty/staff and by commuting students from 1990-2002 in metric tonnes of CO_2 equivalents. The data trends are shown by best-fit linear regression lines.

Athletic Team Travel

The transportation of fall, winter, and spring season athletic teams via coach buses, vans, and cars also contributes to the burning of fossil fuels by the campus and is a substantial anthropogenic source of greenhouse gas emissions. Based on the 2002 travel schedule which was assumed to remain constant since 1990 and fuel efficiencies provided by Arrow and Enterprise Rent-A-Car, it was determined that athletic team travel utilizes 3,027.69 gallons of diesel fuel per year (which is more than is utilized by the campus diesel fleet each year), and 910.97 gallons of gasoline (Appendix A3)[14]. This amounts to a total of 43.07 metric tonnes of CO_2 equivalents per year in direct and upstream emissions. Again, this tonnage is assumed to have remained constant over the eleven years preceding 2002, the year from which the data was obtained[15].

Overall Transportation Trends

The burning of fossil fuels from the utilization of automobiles emits carbon dioxide and other climate-altering greenhouse gas emissions into the atmosphere. Automobile transportation is exacerbating the effects of global warming as the average fuel efficiency of cars decreases due to a preference for larger vehicles. According to the US EPA, the national average for automobile fuel efficiency has decreased from 25.2 miles per gallon in 1990 to 24.0 miles/gallon in 2002. Nationally, transportation is having an increasing effect on emissions and climate change which is consistent with trends at Connecticut College. Its effects are in fact underestimated by this study because it does not include the effects of students who live on campus and who travel from various states and countries (98% of the student body), the regular deliveries of food and other supplies to the college, or the effects of students and faculty members traveling to various conferences or overseas.

Within the transportation sector, commuting faculty and staff are the largest source of emissions. They account for about 12% of the total direct and upstream emissions annually. Although this percentage has remained constant, emissions have increased from 1,724 metric tonnes of CO_2 equivalents per year to 2,614 per year. The campus fleet is the second largest contributor to overall transportation GHG emissions as it accounts for about 2% of overall emissions.

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[14] Personal communications. Arrow Bus Waterford Dispatch, phone: 860-443-1831, & Enterprise Rent-A-Car, phone: 860-442-8333

[15] Data obtained from Judy Richard, Athletic Department Coordinator, phone; 860-439-2541

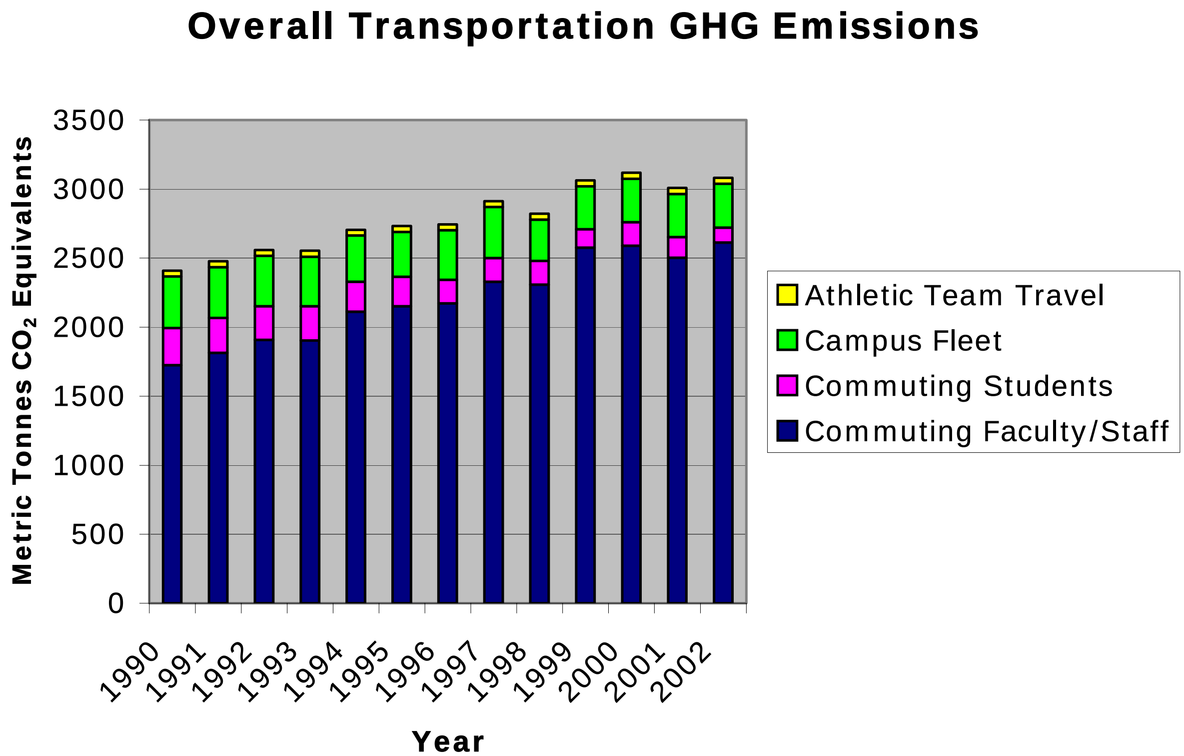

Figure 14: A breakdown of the sources of transportation-related emissions from 1990-2002 in metric tonnes of CO_2 equivalents.

Sector II: Waste

The disposal of municipal solid waste (MSW) and its transport to facilities in the New London area together generate several metric tonnes of greenhouse gas emissions each year. According to Connecticut state law, all MSW generated by the campus which cannot be recycled must be incinerated. The emissions produced by the incineration of this solid waste have increased by 32.57% since 1990 and are thus contributing increasingly greater portions of the total amount of emissions. This is directly the result of an increase in the tonnage of MSW disposed of by the campus community every year (Figure 15). Causes may include increases in the student body population, or perhaps decreased attention paid to the recycling program.

The disposal of bulky waste from construction and other activities was not counted as part of this inventory since the school does not keep records of the tonnages disposed[16].

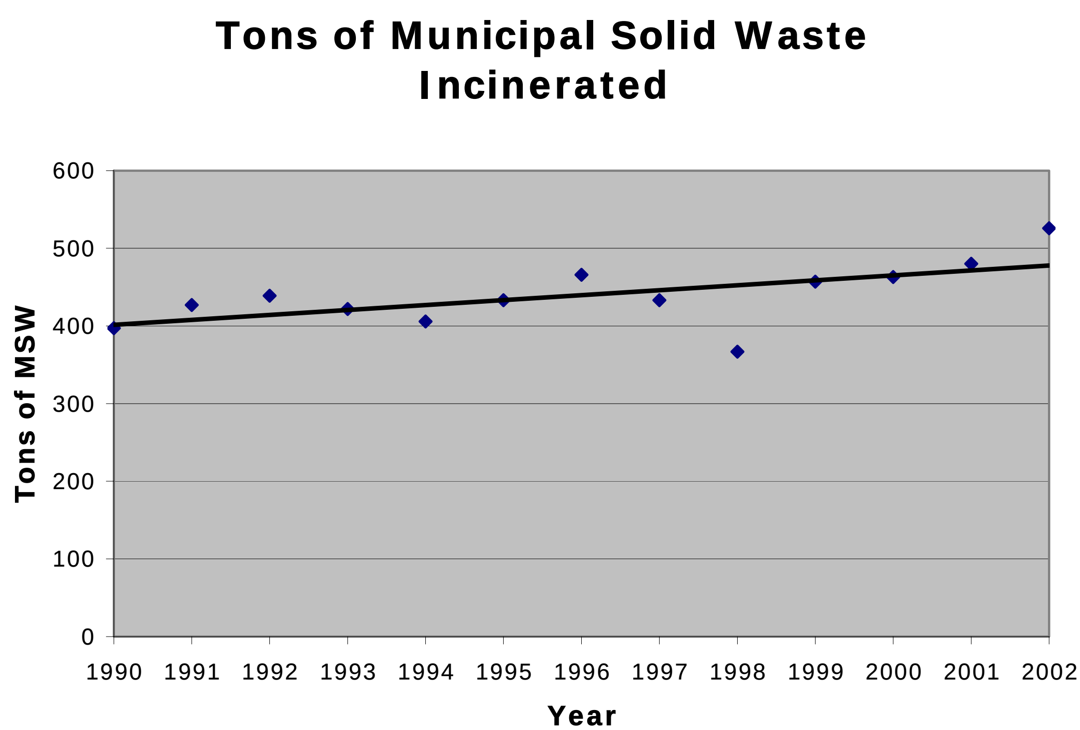

Figure 15: Tons of municipal solid waste incinerated by Connecticut College from 1990-2002 as shown by a best-fit linear regression line.

Recycling Program

In 1970, Connecticut College became one of the first colleges in the nation to promulgate a campus-wide recycling program. Over the years, it has grown from simply newspapers to magazines, corrugated cardboard, office paper, co-mingled containers, light bulbs, Styrofoam packing material, food waste, and cooking oil. In addition, Connecticut College utilized a tub grinder under a contract with the Southeastern Connecticut Regional Resources Recovery Authority from 1999 –2002 in order to chip scrap lumber and wood waste[17].

In each room of the 22 residential dormitories on campus are three Rubbermaid containers for office paper, magazines, as well as bottles and cans. Each floor also has at least one central recycling location. Every dorm has a student-elected Environmental Coordinator to oversee its recycling program. The academic and administrative buildings

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[16] Personal communication. Jim Luce, Connecticut College Grounds Supervisory, phone:860-439-2259

[17] Recycling Info, Connectictut College http://camel2.conncoll.edu/ccrec/greennet/Operations/Recycling_…body_recycling_info.htm

are set up in much the same way, thus the recycling program significantly decreases the amount of MSW incinerated by the campus (Figure 16).

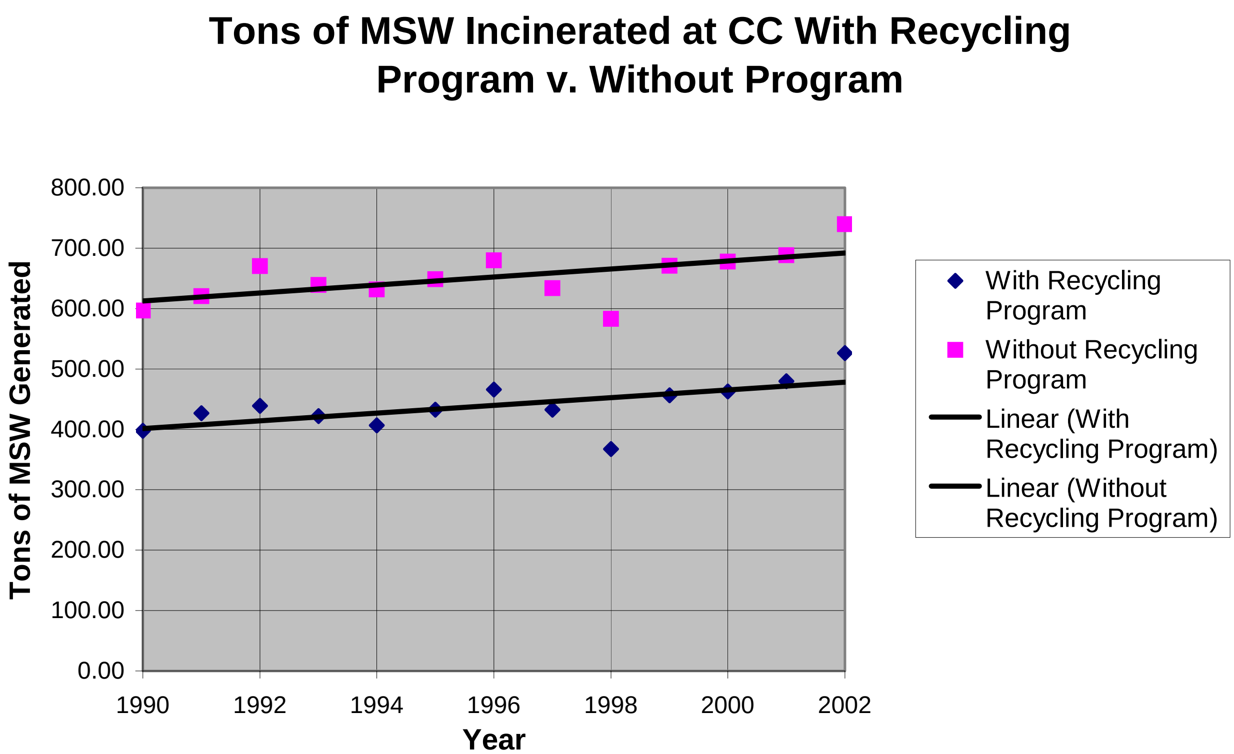

Figure 16: A comparison between the tons of MSW incinerated by the college with its recycling program versus without the program, shown with best fit linear regression lines (Appendix A).

Sector III: Refrigerants and Other Chemicals

Due to the phasing out of ozone-depleting substances such as Cloroflurocarbons (CFCs) under the Montreal Protocol as well as the US Clean Air Act Amendments of 1990, the use of alternative refrigerants like Hydroflurocarbons (HFCs) and Perfluorocarbons (PFCs) has increased. HFCs and PFCs are both powerful GHG gases with long atmospheric lifetimes. Connecticut College keeps records regarding the amount of these refrigerants that are lost during the normal recharging of refrigeration units along with any leaks that occur as all universities must report their flurocarbon release to the US Environmental Protection Agency. However, these records were not made available due to the time constraints of physical plant employees.

Conclusions

Overall Trends in Emissions

Total emissions over the past twelve years have increased by about 25% since 1990. This increase may be partially due to the rise in the student body population over 1,900, however the emissions and energy use per student have both increased by over 30 % which is a population-independent factor. Therefore, the total increase is more likely due to the addition of several buildings and the renovation of existing facilities with air conditioning, the increase in distance traveled by commuting faculty/staff, and several extremely cold winters during the 90's. There has also been an increase in the utilization of electrical equipment by the campus due to increased technologies such as classrooms with laptops at each desk, and nearly every faculty member and student now owns a computer. Connecticut College recognizes its increased impact on global climate change through increased energy and fuel usage and is taking a proactive stance to ameliorate these effects.

Current Mitigation Measures

Renewable Energy

As a result of a student body petition along with the efforts of several dedicated individuals, Connecticut College began to purchase a significant portion of its energy from renewable sources beginning in the spring of 2001. Students agreed to pay an additional $25 in tuition to fund the school's purchase of 17% renewable energy from the Connecticut Clean Energy Coop. After this direct purchasing capability became no longer available, Connecticut College began purchasing renewable energy certificates from EAD Environmental. Although the college was not directly receiving renewable energy through the New England power grid, the purchase of certificates supported the generation of 100 percent wind power in the United States and offset the amount of emissions generated by 22% of the total electricity purchased by the school.

In 2003, Connecticut College is proud to announce it is offsetting 45% of its electricity usage with the purchase of renewable energy certificates as part of a two-year deal with EAD Environmental. Ultimately, the college would like to offset 100% of the emissions generated by its energy purchases with these certificates and eventually move to purchase renewable energy directly.

The Klinki Forestry Project

In coordination with the non-profit organization Reforest the Tropics, Inc. of Mystic, CT, the college launched a Costa Rican/United States Joint Implementation Project to mitigate its impact on global warming in August of 1999. This project involves an agreement with farmers of Costa Rica to plant enough acreage of forest to offset the carbon emissions generated by the Crozier-Williams Student Center, amounting to 593.3 tons/year, for the next 25 years. The specially designed reforestation of pastureland on a farm called Las Delicias which covers 37.1 acres is comprised mainly of the Klinki tree

(*Araucaria hunsteinii*) which can reach heights over 130 feet and can thus sequester a large amount of carbon[18]. Several other native species have also been planted in order to provide for biodiversity. The Kinki Project was the first effort of its kind at the college level to compensate for GHG emissions.

The Park Solar Array

In 1999, a 10 kW array of solar panels was installed on the roof of the Park residence hall. The electricity generated from the conversion of sunlight by these panels which amounts to 42.86 kW/year is utilized to offset the power required to operate a boiler plant added that same year (Appendix A). Connecticut College hopes to install additional solar panels in the future in order to further convert the campus to "green" sources of energy.

Description of Phase II

This report is considered Phase I of a several step process as defined by Connecticut College's partnership with Clean Air-Cool Planet. A supplement to this inventory, Phase II, is currently underway as an individual study in the Department of Economics in which the costs and benefits of various emissions reductions policies are being investigated. This study is hoped to determine the least-costly methods by which Connecticut College can finance reductions in order to meet the standards of the Kyoto Protocol.

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Appendix A: Methodological Notes & Calculations

A1: Commuting Students

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[18] *Meeting the Challenge of Climate Change by Compensating for Connecticut College Carbon Dioxide Emissions in Costa Rican Farm Forests*, Professor William Niering, Botany Department Connecitcut College & Dr. Herster Barres, Reforest the Tropics, Inc., June 1999

The emissions generated by fall/spring commuting students were calculated using the follow assumptions and calculations. The number of commuting students during the fall and spring semesters was determined from student directories from 1990-2003 as was the average distance traveled each year by entering each address into mapquest.com. It was assumed that students made 1 round trip per day for 104 days of the year based on the school calendar. These figures were all multiplied to determine the total number of miles traveled by fall/spring commuting students each year. Using EPA national averages for each year's vehicle fuel efficiency, the total emissions generated by the gasoline usage of student commuters was calculated using Clean Air-Cool Planet's Emissions Calculator.

The emissions generated by summer school students were calculated by multiplying the following data. First, the number of summer school students per year was 43 students in 2002 and because records are not kept of previous years' student populations, this figure was used for each year beginning in 1990. Using the addresses of these students and entering them into mapquest.com, it was determined that in 2002 students traveled an average of 36 miles to campus. Again, because earlier data was not available, this was assumed to remain constant since 1990. Based on the summer class schedules and students enrolled in each class given by the Office of Records and Registration, it was determined that students commuted 12.14 days per year which was also assumed to have remained constant since 1990. Multiplying this data and then utilizing EPA national averages for fuel efficiencies each year, the total number of gallons/year utilized by summer school students was calculated. The emissions generated by this gasoline usage were calculated using Clean Air-Cool Planet's Emissions Calculator.

A2: Commuting Faculty & Staff

The total emissions generated by faculty commuters was calculated in the following way. First it was assumed that each faculty member makes 1 round trip per day, and according to a survey issued to faculty members which received a response rate of about 25% , faculty members travel an average of 212.33 days/year. The average miles traveled per round trip was calculated by entering addresses from directories 1990-2003 into mapquest.com. These figures multiplied by the number of faculty members each year gives the total miles traveled per year. Using EPA national averages for vehicle fuel efficiencies each year and the Emissions Calculator, the resulting emissions from this travel was determined.

The total emissions generated by commuting staff members was calculated in the same manner, however the number of days traveled per year was slightly different. This was determined to be 319.22 days per year based on an average number of vacation, holiday, and sick days provided by Human Resources.

A3: Athletic Team Travel

Because the travel schedule for the fall, winter, and spring seasons from 2002-2003 were the only records available regarding athletic team travel, the calculations for this year were assumed to have remained constant since 1990. This calculation was broken down into travel by coach buses, minivans, vans, and cars as each have a different fuel efficiency. The miles/gallon of each vehicle type was determined by contacting Arrow Bus, Enterprise Rent-A-Car, and Usave Auto Rental to determine the models of vehicles rented by Connecticut College. The respective automakers of these car models were then contacted to obtain an average fuel efficiency over the past ten years which was determined to be 7.5 miles/gallon for the coach buses, 21.5 mi/gal for minivans, and 16.5 mi/gal for the vans. The EPA national average for car fuel efficiency in 2002 was also utilized which is 24.0 mi/gal. The total distance traveled by each vehicles types was then calculated by determining the total number of trips to various colleges and entering their respective addresses into mapquest.com. The total gallons of diesel fuel and gasoline fuel utilized per year were determined and converted into emissions utilizing Clean Air-Cool Planet's Emissions Calculator.