University of New Hampshire
Durham Campus

Greenhouse Gas Emissions Inventory
1990-2000

A collaborative project of the
UNH Office of Sustainability Programs
and
Clean Air - Cool Planet

May 2001

Clean Air-Cool Planet is an action-oriented advocacy group that seeks to reduce the threat of global warming by engaging all sectors of civil society to take actions that lead to rapid cuts in greenhouse gas emissions. Based in Portsmouth, NH, CA-CP is active throughout New England, New Jersey and New York.

Clean Air-Cool Planet's higher education program is designed to engage administrators, students, faculty, and staff in the global climate change discourse by increasing awareness about the issue and catalyzing direct action to reduce greenhouse gas emissions from campuses throughout the northeast.

If you would like to learn more about our work, please contact us at:

Clean Air-Cool Planet
100 Market Street, Suite 204
Portsmouth, NH 03801
Phone: 603.422.6464
Fax: 603.422.6441
e-mail: cgarland@cleanair-coolplanet.org
www.cleanair-coolplanet.org

The mission of the Office of Sustainability Programs at the University of New Hampshire is to unite the university community in the common purpose of education and institutional change for balancing economic viability with ecological health and human well-being. Our goal is to build a sustainable learning community at UNH that serves as a model for other communities.

We have program initiatives in transportation demand management and global change; food and society; integrated waste management; sustainable landscaping and sustainability and culture.

If you would like to learn more about our work, please contact us at:

Office of Sustainability Programs
107 Nesmith Hall
University of New Hampshire
Durham, NH 03824
Phone: 603-862-4088
Fax: 603-862-0785
www.sustainableunh.unh.edu

Second Printing

Adam Wilson
May 2001

Acknowledgments

This project was funded by Clean Air – Cool Planet in collaboration with the UNH Office of Sustainability Programs. Cameron Wake from the Climate Change Research Center at UNH provided guidance and countless improvements. Jim Dombrosk from the UNH Energy Office was instrumental in providing much of the data needed for the inventory and advice on the final report.

Table of Contents

Executive Summary

This report summarizes the anthropogenic greenhouse gas emissions for the University of New Hampshire, Durham Campus, from 1990 – 2000. The emissions are reported in Metric Tonnes Carbon Dioxide Equivalents, according to their Global Warming Potential (GWP) to provide the relative contribution of each gas to climate change forcing. The inventory follows the guidelines of the Intergovernmental Panel on Climate Change (IPCC), a panel of thousands of international scientists organized by the World Meteorological Organization and United Nations Environment Programme. These guidelines were adapted for use at a University. The purpose of completing an inventory of anthropogenic greenhouse gas emissions is twofold: first, to better understand the sources of emissions and second, to initiate the process of reducing them.

Human activities have led to an “enhanced greenhouse effect,” also known as global warming. Since the dawn of the industrial age, carbon dioxide concentrations have risen almost 30%, methane has more than doubled, and nitrous oxide has increased about 15%. The IPCC reported that “the balance of evidence suggests a discernible human influence on global climate.” It is certain that human activities have been significantly increasing the amount of gases in the atmosphere that contribute to this effect. While it is unclear exactly what the impacts of a rapidly warming planet will be, it is clear that there will be changes.

The global average surface temperature has increased over the twentieth century by about 0.6^{o}C. It is very likely that the 1990s was the warmest decade and 1998 the warmest year in instrumental history, since 1861. Satellite data shows that there was likely a 10% decrease in snowcover since the late 1960s in the Northern Hemisphere. Northern summer sea-ice extent has decreased by 10-15% and become 40% thinner. Tide gauges have shown that the global average sea level rose 0.1-0.2 meters during the twentieth century. These global changes will be seen in the New England region and New Hampshire as well. For example, the temperature in Hanover, NH has increased over 1^{o}C and precipitation has decreased by as much as 20% around the state over the last century. At Seavy Island/Portsmouth, NH, sea level is rising by almost 0.18 meters (7 inches) a century.

With over 15,000 community members, UNH consumes a large amount of energy and therefore is responsible for a significant quantity of greenhouse gas emissions. As a microcosm of society at large, studying UNH's energy use and emissions provides the opportunity to reduce those emissions and educate the University community about the significance of energy choices and climate change.

This inventory represents the first step of a five-step plan undertaken in the collaboration between Clean Air - Cool Planet and the UNH Office of Sustainability Programs. The goal is to increase energy efficiency, reduce greenhouse gas emissions, and utilize the process as an educational tool for the university community. The five steps are as follows:

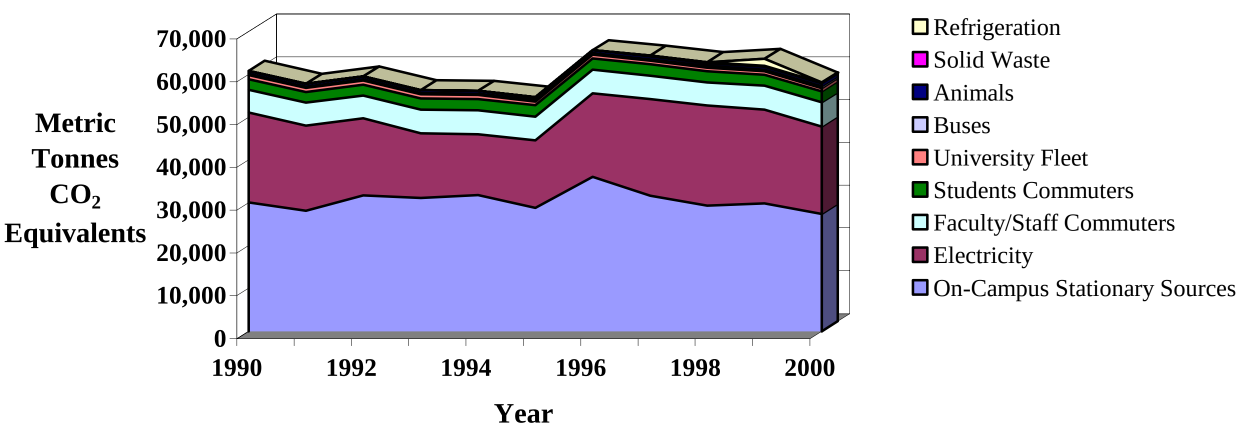
1 Complete an inventory of UNH's greenhouse gas emissions each year from 1990-2000
2 With UNH's assistance, adopt greenhouse gas emission reduction targets and timelines
3 Develop a strategic plan to meet reduction targets
4 Implement the strategic plan
5 Monitor the progress over time

UNH Emissions: Major findings

- UNH emits about 60,000 Metric Tonnes of Carbon Dioxide Equivalents each year.
- There has been a net decrease (-4.5%) in total emissions from 1990-2000 (Figure ES-1)

Figure ES-1: Total UNH Direct Emissions 1990-2000

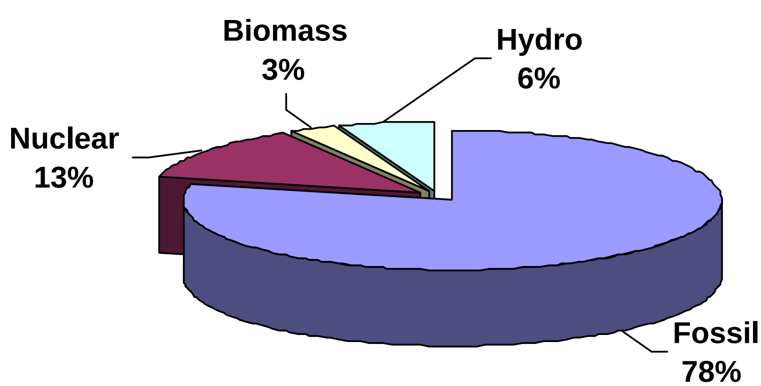
Electricity emissions are those from electric production, which are released off-campus. On-campus stationary sources are all fuels burned on campus except those used for transportation, for purposes such as heating and cooking.



- Energy use per square foot has decreased (15%) from 213 kBtu per SF in 1989 to 181 kBtu per SF in 2000.
- Total energy use has increased (+5.0%) and energy use per student has also increased (+1.2%) from 1990-2000, but emissions per student has decreased (-7.6%) from 1990-2000
- Total emissions have decreased over the decade despite increasing energy use
- Changes in fuel types by both the University and its electric providers have resulted in fewer emissions per unit of energy
- Energy efficiency projects undertaken by the UNH Energy Office have resulted in both reduced consumption and emissions
- UNH relies on fossil fuels (coal, oil, gasoline, diesel, natural gas, and propane) for 78% of its energy needs (Figure ES-2).

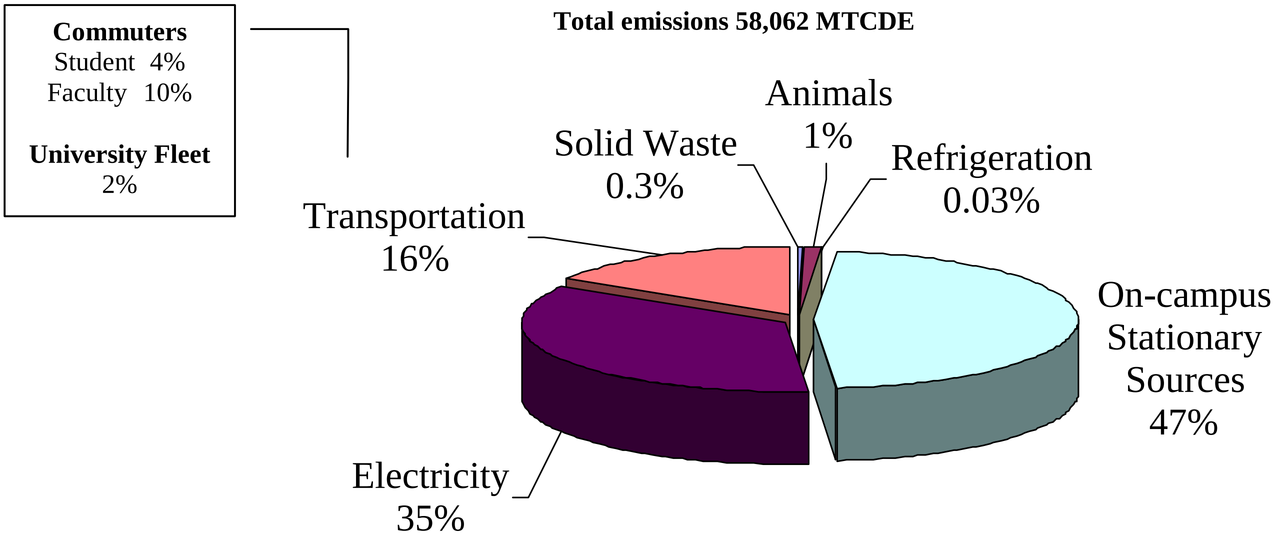
Figure ES-2: UNH's Energy sources, Fiscal year 2000.

Includes on-campus production, off-campus electric production, and transportation. "Hydro" is hydroelectric power production, "biomass" is mostly wood with some refuse.



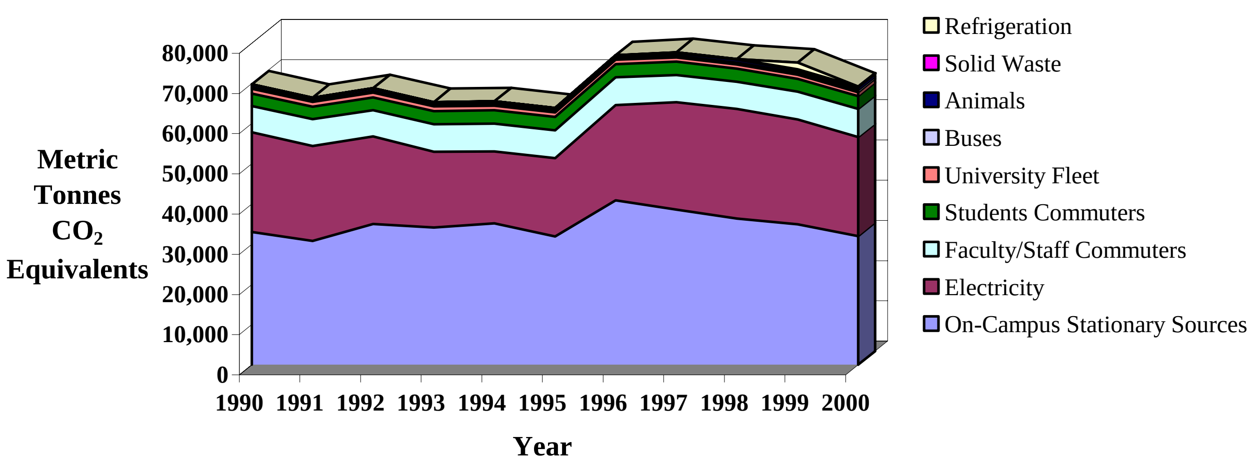
- The majority of UNH's emissions comes from on-campus stationary sources (47%) and electricity (35%), with all forms of transportation adding up to 16% of total emissions. Solid waste disposal, agriculture and refrigerant releases make up the remaining 2%. (Figure ES-3)

Figure ES-3: Sources of UNH's Emissions, by percent, for Fiscal Year 2000



- UNH's upstream emissions were also calculated. These are the emissions associated with the collection of the source fuel (such as crude oil), the transport, storage, and refining of the fuels as they are brought to the location of combustion (such as the automobile or University boiler). For example, it takes fuel to power an oil barge across the ocean or drive a tanker truck to deliver gasoline. When upstream emissions are included, total emissions increase by about 16% (Figure ES-4)

Figure ES-4: Direct and Upstream Emissions



Conclusion

UNH should be commended for keeping emissions relatively steady over the past decade. Despite a growing population of faculty, staff, and students, greenhouse gas emissions have not increased. This is primarily due to a shift from carbon intensive production such as the incinerator, to natural gas on campus. The energy efficiency projects of the UNH Energy Office have also played a major role. The 4,500 metric tonnes of carbon dioxide emissions avoided annually because of these projects would have accounted for over 7% of the total emissions. If it were not for the careful management of UNH's energy infrastructure by the Energy Office, it is likely that total emissions would have reflected the growing population and appetite for energy of the UNH community and the nation in general. The efficiency projects undertaken by the Energy Office save $4 million a year (compared to similar sized schools in 2000) in reduced consumption according to a study completed by the US Department of Energy.

The fuels used to produce our electricity (although UNH has no direct control over them) have also shifted to less carbon intensive fuels like natural gas, biomass, hydroelectric, and nuclear. This shift should not put UNH completely at ease, however, for despite less greenhouse gas emissions, these fuel sources are have many environmental and social impacts. The problems and safety of nuclear waste disposal are manifold and the flooding of huge tracts of land for hydropower create environmental and social problems we are just beginning to understand.

UNH electric use has increased 15% over the decade, while on-campus energy production has increased 3.5%. This increase has surpassed the increasing size of the student body, as there has been a 1.2% increase in energy use per student. However, energy use per square foot has decreased 15% from 213 kBtu per SF in 1989 to 181 kBtu per SF in 2000. Despite the great work of the UNH Energy Office, it is clear that UNH is following the national trend towards more energy intensive operations and therefore unlikely that UNH's emissions will continue to decrease without continued conscious decisions and management plans.

UNH energy policy, including the efficiency projects of the energy office have to date been driven largely by economics and technology. However two factors point to the importance of placing UNH energy policy in a broader educational context: first, as noted above, energy use will likely continue to increase without purposeful policies to mitigate that trend that include an explicit community ethic to conserve energy. Second, with the establishment of the its Office of Sustainability Programs in 1997, UNH has committed itself to a university-wide educational goal of ensuring that all of its graduates develop the competence and character to advance sustainability in their civic and professional lives. This educational goal can only be achieved through modeling best practices in its energy policies as well as all other areas of UNH operations, and integrating those practices into the formal curriculum.

OSP's partnership with Clean Air - Cool Planet, which was initiated with this inventory project, is part of a broader Climate Education Initiative developed to address these educational issues. Other collaborators include the Climate Change Research Center (CCRC) of the UNH Institute of Earth, Oceans and Space, the Campus Energy Office, the UNH Transportation Policy Committee, and Facilities Design and Construction. One project of note is a general education course on global environmental change in which students negotiate implementation of the Kyoto Protocol at UNH. Students first interview and then play the role of senior administrators and other UNH decision-makers and then specify policies and practices to achieve reduction.

Recommendations

UNH has the opportunity to actively reduce greenhouse gas emissions. The work of the UNH Energy Office has shown that emission reduction is not only possible, but can also be economically advantageous. To continue reducing emissions, the following principles should be considered:

- As part of the UNH Climate Education Initiative, the OSP, UNH Energy Office, the Climate Change Research Center, and relevant departments should strengthen their collaboration and coordination to: advance greater energy efficiency in all UNH operations, participate in regional climate impact assessment research, and strengthen innovative curriculum in general education and in the emerging Masters of Public Health Program.
- UNH should continue to work towards more energy efficient construction, operation, and policy.
- UNH should approach energy decisions keeping in mind not only the economic cost, but also the environmental effects and educational opportunities of efficient energy production and consumption.
- UNH should incorporate sustainable construction and design principles into all building renovations and new construction standards.
- UNH should pursue the construction of a co-generation power plant that could supply the university with energy efficient heat and electric. This type of plant uses heat produced in electric generation to heat buildings, rather than wasting two-thirds of the generated energy like most power generating facilities.
- With the deregulation of the electric market, UNH should factor the educational and social benefits of cleaner power into the decision of what kind of electric production methods (such as fossil, nuclear, hydroelectric, biomass, solar, wind, or others) to support.
- UNH should incorporate principles of Transportation Demand Management (TDM) into decisions made regarding all forms of transportation. TDM is a tool to maximize mobility while reducing congestion and the resulting pollution. TDM includes: campus shuttles and an efficient bus system, car and van pooling, parking management strategies, alternative mode incentive programs, bicycles and pedestrian planning, and housing and scheduling management.

Author's Note

Like it or not, we live in an age of difficult decisions and major consequences. In the past few hundred years, humans have undergone some of the most significant shifts in lifestyle since our ancient origin. We have developed the most energy intensive culture on the planet -- a culture in which life without a steady supply of electricity, gasoline, and other finite fuels seems unimaginable, a culture in which the personal automobile (or two or three) has gone from being a luxury to a virtual necessity.

There is much to be said for the availability of cheap energy. Argued to be the foundation of our economy, cheap energy enables us to provide, to create, and to travel. However, there are costs not tallied in the economic bottom line. Our extreme energy consumption has brought with it some extreme consequences.

We are living through the profound discovery that our use of fossil fuels and other chemicals is changing the climate of planet Earth. No longer are our actions limited to our region or even just what lies downstream or downwind of us. We are changing the global climate and can only estimate the impact. A changing climate could bring about more severe and frequent killer heat waves in our cities, sea level rise that may inundate coastal areas, more infectious diseases as disease-carrying insects and rodents spread to new areas, more severe storms as rainfall patterns change and warming leads to more energy in the atmosphere, and more severe droughts as increased heat leads to more rapid evaporation. These are direct, tangible threats to humans (and our economies) and, equally important, to the natural and social systems we depend on for food, materials, and replenishment.

I am not a dreamy environmentalist. I am not implying that a shift away from fossil fuels and energy-intensive lifestyles will be an easy one that can be accomplished with a flick of an administrative pen or a simple decision by the Board of Trustees. I recognize the immensity of the challenges we face in balancing our economic viability with ecological sustainability. But I also recognize that it is a shift we have to make. We found and have taken full advantage of the resources available to us to create what we have today. Now is the time to reflect on the costs of our journey and to plan for the future.

The *University of New Hampshire Greenhouse Gas Inventory 1990-2000* represents one step towards recognizing climate change and taking action to reduce our impact. Virtually every action taken to reduce our emissions will not only curb climate change, but will also benefit the university community. Imagine congestion-free streets, smaller energy bills, cleaner air, and perhaps most importantly, the ability to honestly and actively educate the student body (and employees) about the pressing issue of climate change and the importance of civic responsibility. There's no better opportunity for a university to test the relevance of its education than by using that education to better the immediate -- and global -- environment.

Adam Wilson, Intern
Clean Air - Cool Planet
Office of Sustainability Programs

Introduction

This report summarizes the anthropogenic greenhouse gas emissions for the University of New Hampshire from 1990 – 2000. The emissions are presented in both weight of the gases emitted and in Metric Tonnes Carbon Dioxide Equivalents, according to their Global Warming Potential (GWP) to provide the relative contribution of each gas to climate change[1]. The inventory follows the guidelines of the Intergovernmental Panel on Climate Change (IPCC) that were adapted for use at a University[2]. The purpose of completing an inventory of anthropogenic greenhouse gas emissions is twofold: first, to better understand the sources of emissions and second, to investigate the possibility of reducing them.

Climate Change – The Gases

Climate change refers to "fluctuations in the temperature, precipitation, wind and other elements of Earth's climate system[3]." These fluctuations can be influenced by a variety of natural factors including changes in orbital parameters, volcanic activity, and solar irradiance. Climate change can also be brought about with a change in the composition of the atmosphere. The planet is kept at a hospitable average temperature of 15.5^{o}C (60^o F) due to the insulating layer of greenhouse gases that encapsulate the surface[4]. These gases, which include water vapor, the most significant greenhouse gas, absorb some of the sun's energy and keep the enclosed surface warm. This phenomenon, known as the "Greenhouse Effect," is a necessary component of the many systems needed to support life on Earth.

However, human activities have led to an "enhanced greenhouse effect," also known as global warming (Figure 1). Since the dawn of the industrial age, carbon dioxide concentrations have risen almost 30%, methane has more than doubled, and nitrous oxide has increased about 15%. The IPCC has reported that "the balance of evidence suggests a discernible human influence on global climate." [5] It is certain that human activities have been significantly increasing the amount of gases in the atmosphere that contribute to this effect. While it is unclear exactly what the impacts of a rapidly warming planet will be, it is clear that there will be significant changes. There are many gases that contribute to the greenhouse effect, some directly and others indirectly. The most important of these gases have been identified by IPCC, and focused upon by the international community as the emissions that should be reduced to curb the "enhanced greenhouse effect." The primary anthropogenic greenhouse gases are:

Carbon dioxide	**CO_2**
Methane	**CH_4**
Nitrous oxide	**N_2O**
Halocarbons	**PFCs and HFCs**
Sulfur Hexaflouride	**SF_6**

[1] See the section entitled Global Warming Potentials below for an explanation.

[2] The IPCC, established in 1988, was created by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) with the recognition that the Earth's climate may be changing. The IPCC completed its First Assessment Report in 1990 which played an important role in establishing the Intergovernmental Negotiating Committee for a UN Framework Convention on Climate Change (UNFCCC) by the UN General Assembly. The role of the IPCC is not to carry out research but to assess the "scientific, technical and socio-economic information relevant for understanding the risk of human-induced climate change." Three working groups have been formed, to assess the science, impacts and possible mitigation of climate change. Each group produces a report every five years, the most recent released the spring of 2001. http://www.ipcc.ch

[3] The Earth's climate system comprises the atmosphere, oceans, biosphere, cryosphere, and geosphere. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 1998*, 2000 U.S. E.P.A. http://www.epa.gov/globalwarming/publications/emissions/us2000/executive_summary.pdf

[4] *Climate Change and New Hampshire*, US EPA, 1997 http://www.epa.gov/globalwarming/impacts/stateimp/newhampshire/index.html

[5] *Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change*, 2001, http://www.usgcrp.gov/ipcc/wg1spm.pdf

Carbon Dioxide (CO_2) – Carbon is a continually cycling element that moves between the atmosphere, ocean, land biota, marine biota, and mineral reserves. In the atmosphere, carbon exists primarily as carbon dioxide, which is a part of global biogeochemical cycling. The atmospheric concentration of CO_2 has increased by 31% since 1750 and has likely not been exceeded during the past 20 million years. About three quarters of anthropogenic CO_2 emissions are from burning fossil fuels, the other quarter from land-use changes, primarily deforestation (Figure 2)[6].

Methane (CH_4) – Methane is produced primarily through anaerobic decomposition of organic matter in living systems. It is produced in the stomachs of cows and pigs and from their manure, as well as from rice paddies and landfills. It is also released with the collection, processing, and combustion of fossil fuels. The atmospheric concentration of CH_4 has increased 151% since 1750 and continues to increase. The present concentration has not been exceeded during the past 420,000 years(Figure 2)[6].

Nitrous Oxide (N_2O) – Nitrous Oxide is also produced with the combustion of fossil fuels, as well as in agriculture and some industrial processes. N_2O concentrations have increased 17% since 1750 (Figure 2)[6].

Others: Hydrofluorocarbons, Perfluorocarbons, and sulfur hexaflouride (HFC, PFC, SF_6) – Halocarbons are primarily produced for industrial processes. HFCs were introduced as replacements for ozone-depleting substances, primarily as refrigerants. HFCs and SF_6 are used in aluminum smelting, electric power distribution, and magnesium casting. These chemicals are powerful greenhouse gases and have very long atmospheric lifetimes. The atmospheric concentration of these gases is increasing (Figure 2)[6].

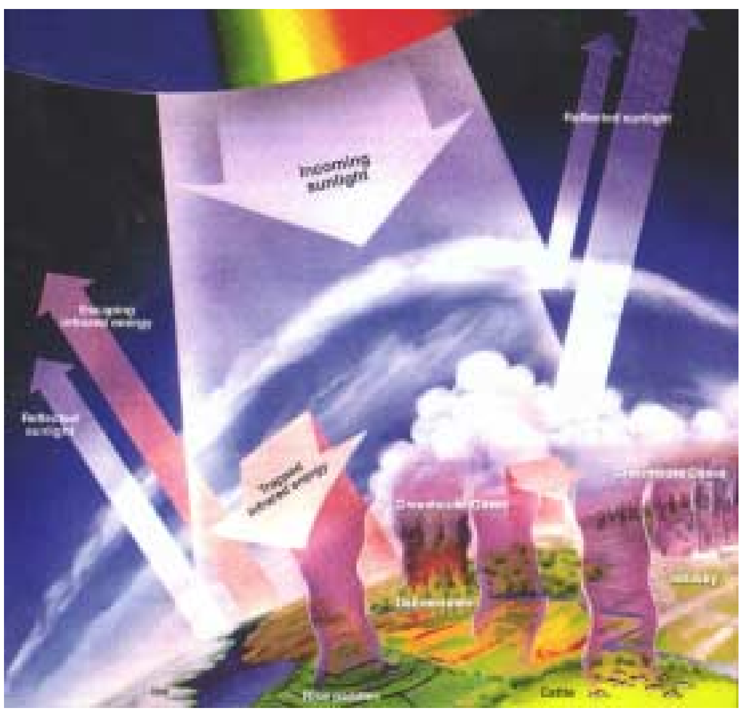


Figure 1: The Greenhouse Effect (Ian Warpole, *Oceanus* magazine, Vol. 35, No. 1, Spring, 1992, the Woods Hole Oceanographic Institution, Woods Hole, MA.) Used with permission.

[6] *Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change*, 2001, http://www.usgcrp.gov/ipcc/wg1spm.pdf

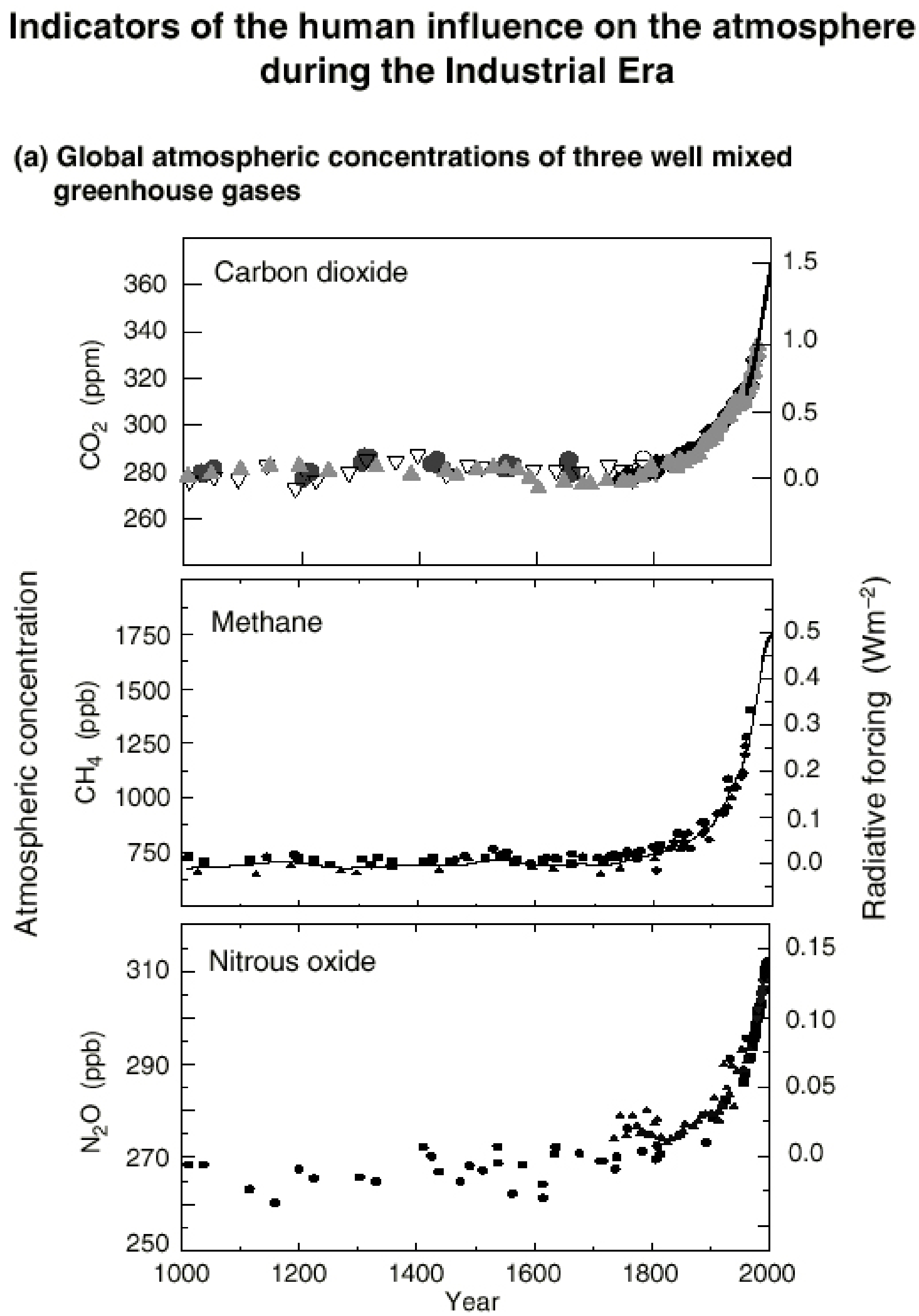


Figure 2: Long records of past changes in atmospheric composition provide the context for the influence of anthropogenic emissions. These graphs show changes in the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) over the past 1000 years. The ice core and firn data for several sites in Antarctica and Greenland (shown by different symbols) are supplemented with the data from direct atmospheric samples over the past few decades (shown by the line for CO_2 and incorporated in the curve representing the global average of CH_4). The estimated positive radiative forcing of the climate system from these gases is indicated on the right-hand scale. Since these gases have atmospheric lifetimes of a decade or more, they are well mixed, and their concentrations reflect emissions from sources throughout the globe. All three records show effects of the large and increasing growth in anthropogenic emissions during the Industrial Era. Source: *Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change*, 2001, http://www.usgcrp.gov/ipcc/wg1spm.pdf

Global Warming Potential

The various greenhouse gases trap the sun's energy to varying degrees. This is called the chemical's radiative forcing (or global warming potential - GWP) and it allows all of the greenhouse gases to be converted to a similar unit of carbon dioxide equivalents. The radiative forcing of a gas is dependent on how it reacts with long-wave radiation coming from the Earth and how long-lived it is (Table 1). For example, one molecule of SF_6 warms the planet to a similar extent as 23,900 molecules of CO_2. The emissions in this report are reported in Metric Tonnes Carbon Dioxide Equivalents (MTCDE). This value is the product of the weight of the gas in Metric tonnes and the GWP (For example, 1 metric tonne of CH_4 is 21 MTCDE). This unit allows for a quick comparison of different gases relative to the effect they have in the atmosphere.

Table 1: Global Warming Potentials and Atmospheric Lifetime of several greenhouse gases[7]

Gas	Atmospheric Lifetime (Years)	Global Warming Potential (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[8]	>48	3,260
Sulfur Hexafluoride (SF_6)	3,200	23,900

Observed Climatic Changes

For the past few decades, scientists have been seeking to understand the complex systems that influence our climate. By employing several avenues of study, from ancient ice core and tree ring analysis to historical records and present day recording, it is clear that climate is changing. The global average surface temperature as increased over the twentieth century by about $0.6^{o}C$ (Figure 3). It is very likely that the 1990s was the warmest decade and 1998 the warmest year in instrumental history, since 1861. Satellite data shows that there was likely a 10% decrease in snowcover since the late 1960s in the Northern Hemisphere. Northern summer sea-ice extent has decreased by 10-15% and become 40% thinner. Tide gauges have shown that the global average sea level rose 0.1-0.2 meters during the twentieth century[9]. The temperature in Hanover, NH has increased over $1^{o}C$ and precipitation has decreased by as much as 20% around the state over the last century. At Seavy Island/Portsmouth, NH, sea level is rising by almost 0.18 meters (7 inches) a century[10].

---

[7] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 1998, 2000 U.S. E.P.A. http://www.epa.gov/globalwarming/publications/emissions/us2000/executive_summary.pdf
Methane GWP includes the direct effects and those effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included. HFC-404a is a mixture of HFC-125, HFC-143a, and HFC 134a.

[8] HFC-404a is a mixture of HFC-125 (44%), HFC-143a (52%), and HFC 134a (4%). Personal Communication, Linwood Marden, Heating/Air Conditioning Specialist, UNH Facilities, 603.862.2658

[9] Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change, 2001, http://www.usgcrp.gov/ipcc/wg1spm.pdf

[10] Climate Change and New Hampshire, US EPA, 1997, http://www.epa.gov/globalwarming/impacts/stateimp/newhampshire/index.html

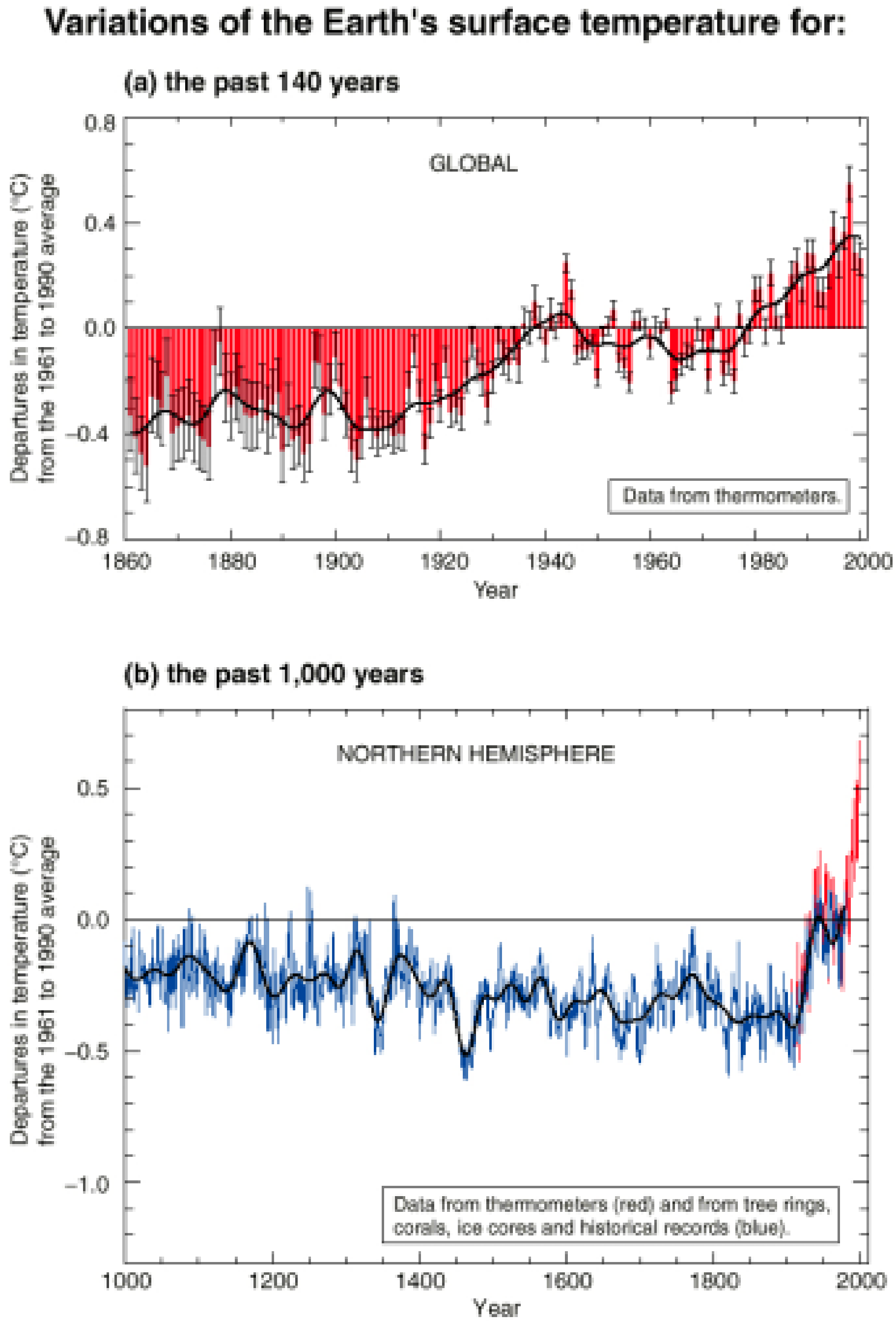


Figure 3: Variations of the Earth's surface temperature over the last 140 years and the last millennium. (a) The Earth's surface temperature is shown year by year (red bars) and approximately decade by decade (black line). There are uncertainties in the annual data (thin black whisker bars represent the 95% confidence range) due to data gaps, random instrumental errors and uncertainties (bias corrections in the ocean surface temperature data and also in adjustments for urbanisation over the land). Over both the last 140 years and 100 years, the best estimate is that the global average surface temperature has increased by 0.6 ±0.2°C. (b) The year by year (blue curve) and 50 year average (black curve) variations of the average surface temperature of the Northern Hemisphere for the past 1000 years have been reconstructed from "proxy" data calibrated against instrumental data. The gray region represents the 95% confidence range in the annual data. These uncertainties increase in more distant times and are always much larger than in the instrumental record due to the use of relatively sparse proxy data. Nevertheless the rate and duration of warming of the 20th century has been much greater than in any of the previous nine centuries. Source: Mann et al., *Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change*, 2001, http://www.usgcrp.gov/ipcc/wg1spm.pdf

Predicted Climatic Changes

Anthropogenic emissions today will continue to influence atmospheric composition through the twenty-first century. While the severity of climate change is uncertain, there will be changes. The global average temperature is projected to increase between 1.4 and 5.8°C between 1990 and 2100. This will probably be the most significant change in climate in the past 10,000 years. This change will affect weather patterns and precipitation worldwide. Sea level is projected to rise by 0.09 to 0.88 meters between 1990 and 2100[11]. In New Hampshire, temperatures could increase by as much as 5.5°C. Sea level rise in Portsmouth, NH, could increase by another 0.45 meters (18 inches) by 2100[12].

Climate Change Impacts

Many of the planet's ecosystems, including human systems, are vulnerable to climate change. Even the slightest changes to temperature and sea level could have major consequences. Globally, we are likely to see increases in frequency and severity of droughts, floods, heat waves, avalanches, and windstorms. These events are likely to increase incidence of death and serious illnesses in older age groups and urban poor, infectious disease epidemics, heat stress of livestock, flood and landslide damage, and forest fires. There will also likely be decreased crop yields and available water for irrigation and other agricultural puposes. [13]

Along with the increase in temperature and sea level, there are a host of other indirect effects of climate change that may impact New Hampshire. Southern New Hampshire already exceeds national ozone pollution health standards, and a warming climate could increase ozone levels in urban areas. Disease carrying insects, such as Lyme disease-carrying ticks, could become more common as their habitat expands northward with warmer weather. Adapting to a 0.5 meter (20 inch) increase in sea-level rise in Portsmouth could cost between $39-$304 million. A changing climate could also affect ecosystem health and even lead to shifts in ecosystem types (see Figure 4). If precipitation decreases significantly, New Hampshire could see a shift from forests to grasslands and pasture. The salt marshes near the University of New Hampshire could be also be adversely affected by changes in runoff and sea level. [12]

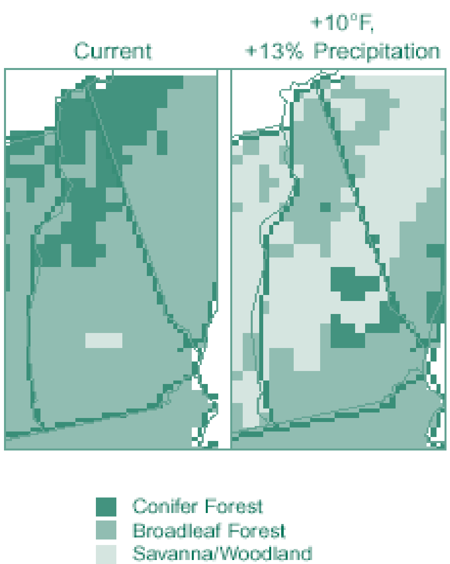


Figure 4: Potential Changes in Forest Cover in New Hampshire with a 5.5°C increase with a 13% increase in Precipitation. Source: Climate Change and New Hampshire, US EPA, 1997, http://www.epa.gov/globalwarming/impacts/stateimp/newhampshire/index.html

[11] *Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change,* 2001, http://www.usgcrp.gov/ipcc/wg1spm.pdf

[12] *Climate Change and New Hampshire,* US EPA, 1997, http://www.epa.gov/globalwarming/impacts/stateimp/newhampshire/index.html

[13] *Climate Change 2001: Impacts, Adaptation, and Vulnerability, Summary for Policymakers, A Report of Working Group II of the Intergovernmental Panel on Climate Change,* 2001, http://www.ipcc-nggip.iges.or.jp/tar/WGII-SPM.pdf

UNH Greenhouse Gas Emissions

The University of New Hampshire, founded in 1866, is a rural campus with about 12,000 students and 2,500 faculty and staff. The campus occupies over 1,000 acres of woods, fields, and developed areas. About half of the student body lives on campus, and few faculty staff or students live farther than 25 miles away. UNH's emissions are divided into four categories: Energy (which includes on-campus stationary sources, the sources of electricity, and transportation), Waste, Agriculture and Refrigeration. Emissions from energy sources make up the vast majority of greenhouse gas emissions, followed by waste, agriculture and refrigeration (Figure 3).

Methods - Scope of Inventory

The methods used to calculate UNH’s greenhouse gas emissions were adapted from the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC). The IPCC created spreadsheets designed for conducting a nation-wide greenhouse gas emissions inventory and provides spreadsheets to assist with the calculations[14]. This report is based on spreadsheets adapted directly from the IPCC spreadsheets (with some sections drawn from the US Inventory and the New Hampshire Inventory as noted). A full set of the spreadsheets used and their explanations are included in the appendix. The University’s emissions sources are divided into four categories: Energy, Waste, Agriculture, and Refrigeration. The energy section includes the emissions created to produce our electricity (even though these were produced off-campus), as well as from on-campus stationary sources (heating and cooking), University fleet transportation, and commuters. The emission estimates in the energy section are based on regional and national average emission factors for the quantities of the various fuels burned. The waste section includes solid and liquid waste disposal and decomposition. The agriculture section includes animal management (enteric fermentation and manure management) but does not estimate soil management emissions (they are insignificant). The refrigeration section includes all released HFC and PFC refrigerants.

There are several sources of emissions that were not included in this inventory. Most notably is the production of materials consumed by UNH. This inventory makes no estimates regarding paper use, food production, or construction materials. While it would be beneficial to complete such an inventory, its complexity is beyond the scope of this project. In addition, this inventory does not estimate the emissions from university community members' off-campus activities (with the exception of their commuter habits of transportation to and from the university). For example, the energy consumption of student or faculty off-campus homes are not included. There is no reliable way to estimate these emissions and even if there were, a boundary must be drawn somewhere or there would be no limit to the emissions associated with the University (i.e. if UNH is responsible for students home energy use, it also could be considered responsible for the energy use of those who provide for the student). Instead, this inventory was focused on the sources of emissions that the University has some direct influence on. UNH has direct control of the type of fuels it uses to produce heat and the energy efficiency of building design. It also has control of how much electricity it uses and may soon have control of how that electricity is produced. UNH can also exhibit some influence on commuter habits by offering alternatives to the personal automobile, a significant source of UNH's emissions. While not completely exhaustive, this inventory can serve as a more-than adequate foundation for assisting in the development of UNH energy policy.

[14] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, IPCC
http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm

CO_2 Emissions from Biogenic Sources

The US and all other parties to the Framework Convention on Climate Change agreed to develop inventories of GHGs for purposes of (1) developing mitigation strategies and (2) monitoring the progress of those strategies. The Intergovernmental Panel on Climate Change (IPCC) developed a set of inventory methods to be used as the international standard. One of the elements of the IPCC guidance that deserves special mention is the approach used to address CO_2 emissions from biogenic sources. The carbon in wood, paper, and grass trimmings was originally removed from the atmosphere by photosynthesis, and under natural conditions, it would eventually cycle back to the atmosphere as CO_2 due to degradation processes. The quantity of carbon that these natural processes cycle through the earth's atmosphere, waters, soils, and biota is much greater than the quantity added by anthropogenic GHG sources. But the focus of the Framework Convention on Climate Change is on anthropogenic emissions - emissions resulting from human activities and subject to human control - because it is these emissions that have the potential to alter the climate by disrupting the natural balances in carbon's biogeochemical cycle, and altering the atmosphere's heat-trapping ability. Thus, for processes with CO_2 emissions, if (a) the emissions are from biogenic materials and (b) the materials are grown on a sustainable basis, then those emissions are considered to simply close the loop in the natural carbon cycle -- that is, they return to the atmosphere CO_2 which was originally removed by photosynthesis. In this case, the CO_2 emissions from wood and biomass are not counted. On the other hand, CO_2 emissions from burning fossil fuels are counted because these emissions would not enter the cycle were it not for human activity. Likewise, CH_4 emissions from landfills are counted - even though the source of carbon is primarily biogenic, CH_4 would not be emitted were it not for the human activity of landfilling the waste, which creates anaerobic conditions conducive to CH_4 formation. Note that this approach does not distinguish between the timing of CO_2 emissions, provided that they occur in a reasonably short time scale relative to the speed of the processes that affect global climate change. In other words, as long as the biogenic carbon would eventually be released as CO_2, it does not matter whether it is released virtually instantaneously (e.g., from combustion) or over a period of a few decades (e.g., decomposition on the forest floor).

Source: *Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste*, US EPA, 1998, www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf)

Total Direct Emissions

The University of New Hampshire has emitted about 60,000 MTCDE each year since 1990. The majority of these emissions comes from on-campus stationary sources (47%) and electricity (35%), with all forms of transportation adding up to 16% of total emissions. Solid waste disposal, agriculture and refrigerant releases make up the remaining 2%.

The University of New Hampshire emissions of about 60,000 metric tonnes of tons of greenhouse gases a year have remained remarkably steady throughout the past decade (Figure 5, Table 2). There was a sharp increase in the 1996-1997 year when Rudman Hall, the addition to the Memorial Union Building, The Whittemore Center and the Chase Oceanography Building all were completed. In addition, that was the first year the residence halls were wired for internet access and cable television, which is likely responsible for some of the increase in the use of electricity. The winter of 1995 was especially mild, so the emissions are the lowest for that year[15].

Figure 5: Total UNH Direct Emissions 1990-2000

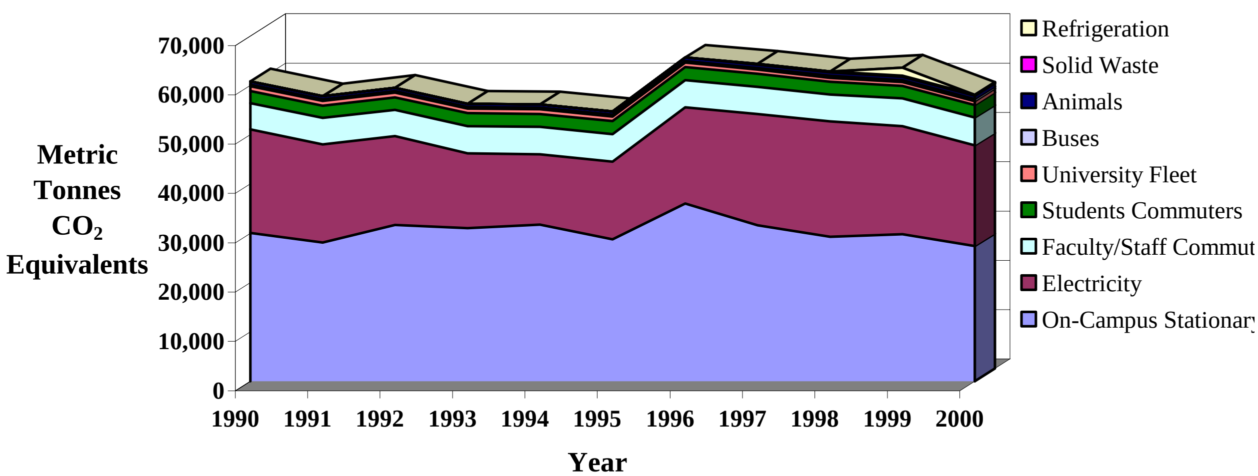


Table 2: Total UNH Greenhouse Gas Emissions (Metric Tonnes Carbon Dioxide Equivalents)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
On-Campus Stationary Sources	30,069	28,110	31,695	31,056	31,747	28,798	36,024	31,604	29,312	29,794	27,376
Electricity	21,025	19,925	18,031	15,175	14,241	15,725	19,499	22,606	23,366	21,933	20,426
Faculty/Staff Commuters	5,274	5,343	5,290	5,498	5,576	5,596	5,554	5,474	5,424	5,609	5,649
Students Commuters	2,502	2,485	2,554	2,620	2,643	2,664	2,646	2,653	2,611	2,551	2,570
University Fleet	944	944	944	944	944	847	897	837	820	792	766
Wildcat Transit	335	335	335	335	335	410	349	340	423	403	413
Animals	649	649	649	649	649	650	656	652	648	645	646
Solid Waste	0	0	0	0	0	0	0	214	206	234	201
Refrigeration	0	0	0	0	0	0	0	0	19	1,638	35
Total	**60,799**	**57,792**	**59,499**	**56,277**	**56,136**	**54,689**	**65,625**	**64,381**	**62,829**	**63,600**	**58,082**

[15] Personal Communication, Jim Dombrosk, UNH Energy Office, jim.dombrosk@unh.edu

Total Direct and Upstream Emissions

A commonly overlooked source of emissions in greenhouse gas inventories is the "upstream emissions;" emissions associated with the recovery and production of used resources. In this inventory the upstream emissions of consumed fossil fuels are estimated (Figure 6, Table 3). This refers to emissions associated with the collection of the source fuel (such as crude oil), the transportation, storage and refining of the fuels as they are brought to the location of combustion (such as the automobile or University boiler). For example, it takes fuel to power an oil barge across the ocean or drive a tanker truck to deliver gasoline. These emissions are estimated in the U.S. Department of Energy Report, *The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation*[16]. However, to meet the guidelines of the IPCC and US EPA, UNH's emissions have been reported both with and without the upstream emissions.

When upstream emissions are included, UNH's total emissions (MTCDE) increase by 16%.

Figure 6: Direct and Upstream Emissions

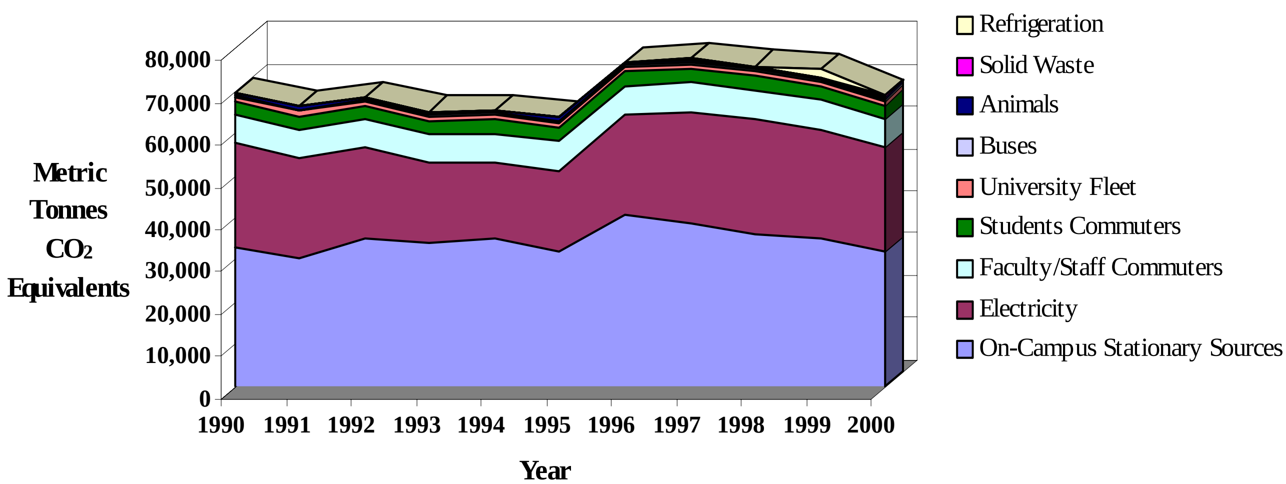


Table 3: Total UNH Direct and Upstream Greenhouse Gas Emissions (Metric Tonnes Carbon Dioxide Equivalents)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
On-Campus Stationary Sources	32,985	30,760	35,012	34,111	35,165	31,875	40,870	38,580	36,349	34,952	32,017
Electricity	24,816	23,669	21,744	18,853	17,890	19,503	23,692	26,687	27,295	26,018	24,579
Faculty/Staff Commuters	6,558	6,644	6,577	6,836	6,933	6,959	6,906	6,806	6,745	6,974	7,024
Students Commuters	3,111	3,090	3,176	3,257	3,287	3,313	3,291	3,299	3,247	3,173	3,195
University Fleet	1,184	1,184	1,184	1,184	1,184	1,062	1,125	1,050	1,028	992	960
Wildcat Transit	413	413	413	413	413	505	430	419	521	496	509
Animals	649	649	649	649	649	650	656	652	648	645	646
Solid Waste	0	0	0	0	0	0	0	214	206	234	201
Refrigeration	0	0	0	0	0	0	0	0	19	1,638	35
Total	**69,717**	**66,410**	**68,755**	**65,304**	**65,522**	**63,867**	**76,970**	**77,707**	**76,056**	**75,123**	**69,165**

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

Trends in UNH Emissions

Total emissions from the decade can be misleading if one assumes that steady emissions means steady energy use. In fact, electricity use has increased by 15% and our on-campus energy production has increased by about 3.5%. The primary reasons our emissions have not increased are due to the changing fuel types in electric production and on campus combustion. In addition, energy use per square foot has decreased 15% from 213 kBtu per SF in 1989 to 181 kBtu per SF in 2000 due to energy efficiency projects[17]. Electricity production has shifted from more carbon-rich fuels like coal and heavy oil to less carbon rich fuels such as natural gas, nuclear, and hydroelectric. During this decade, UNH's fuel sources have also shifted away from the incinerator and fuel oils to natural gas. The University of New Hampshire used more energy in 2000 than it did in 1990, but it used it more efficiently.

When upstream emissions are included with UNH's direct emissions, there is an increase of almost 30% over direct emissions (Table 3, Figure 6). Some fuels, primarily gasoline which is a highly refined fuel, have relatively higher upstream emissions which is visible in the comparison between the direct and upstream figures (Figures 5, 6).

In addition to the total emissions from the university, emissions and energy use per student were also calculated (Table 4). This measure provides a method to compare institutions of different sizes and types of infrastructure. There was a net decrease (7.6%) in emissions per student, most attributable to changes in electric production and university fuel use as discussed above (Table 4). However, despite this decrease, emissions add up to about five thousand kilograms (11,000 pounds) of carbon dioxide emitted per student per year. There has been a net increase in overall university energy use (4.9%) and in energy use per student (1.2%), with some wide fluctuations (Table 4, Figure 7 - 8). The rise in energy use in 1996 is due at least partly to several new buildings coming online as discussed earlier. The dip in 1995 is primarily due to an unusually warm winter.

Table 4: UNH Energy Use and Emission Intensities.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
UNH Electric Use (MWh)	43.344	43.000	43.518	44.105	43.767	45.033	51.098	50.875	48.903	49.859	50.462
Electric Emissions (kg CDE/kWh)	0.485	0.463	0.414	0.364	0.325	0.349	0.382	0.444	0.478	0.440	0.405
Total MTCDE Emissions	**60,799**	**57,792**	**59,499**	**56,277**	**56,136**	**54,689**	**65,625**	**64,381**	**62,829**	**63,600**	**58,082**
% Change from Previous Year		-4.9%	3.0%	-5.4%	-0.3%	-2.6%	20.0%	-1.9%	-2.4%	1.2%	-8.7%
Students	11,566	11,468	11,874	12,257	12,397	12,518	12,414	12,454	12,209	11,857	11,965
MTCDE / Student	5.257	5.039	5.011	4.591	4.528	4.369	5.286	5.169	5.146	5.364	4.854
Total Energy Use (TJ)	958	929	974	958	968	940	1,113	1,119	1,077	1,042	1,008
Energy use / Student (TJ / Student)	0.083	0.081	0.082	0.078	0.078	0.075	0.090	0.090	0.088	0.088	0.084

[17] UNH Energy Office, Jim Dombrosk, jim.dombrosk@unh.edu

Figure 8: Emissions per student (Metric Tonnes CO_2 Equivalents / Student / Year)

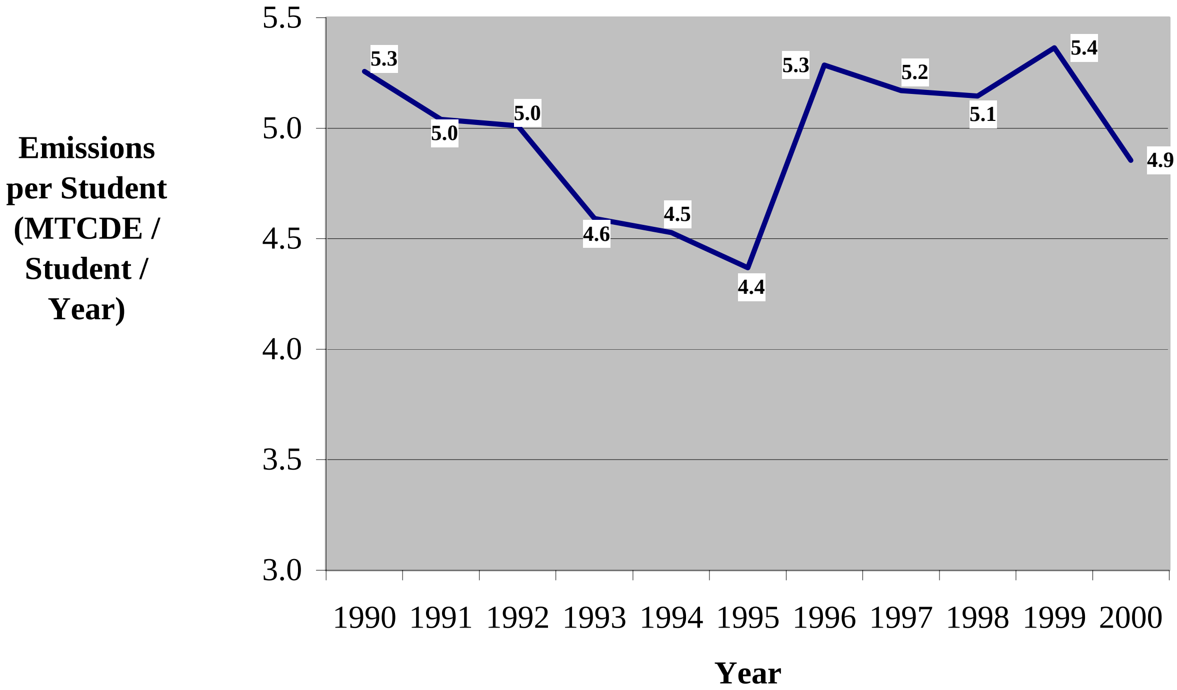
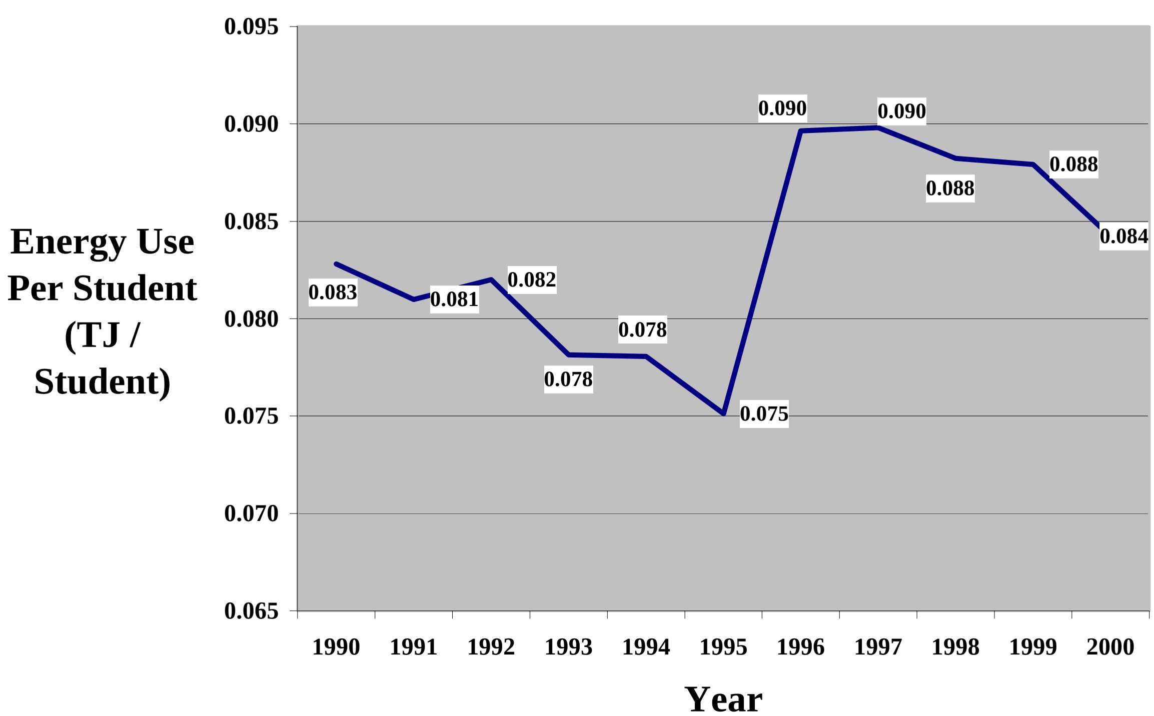


Figure 7: Energy Use per Student (Terajoules / Student / Year)



Emissions by Type of Gas

Of the six greenhouse gases identified in this inventory, carbon dioxide is emitted in the largest amounts by far. Although the other gases have higher global warming potentials that range from 21 times as powerful as CO_2 in the case of methane, to 23,900 times as powerful in the case of sulfur hexaflouride, CO_2 still has the most effect on the atmosphere (Figures 9-10).

Figure 9: UNH Emissions by Gas (MTCDE) Fiscal Year 1990

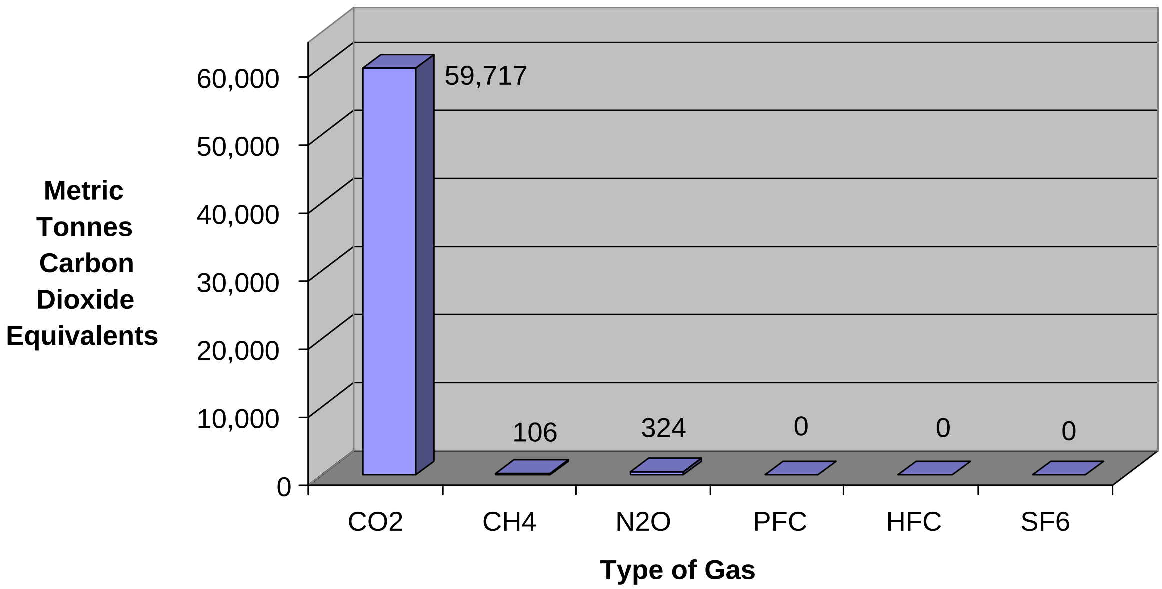
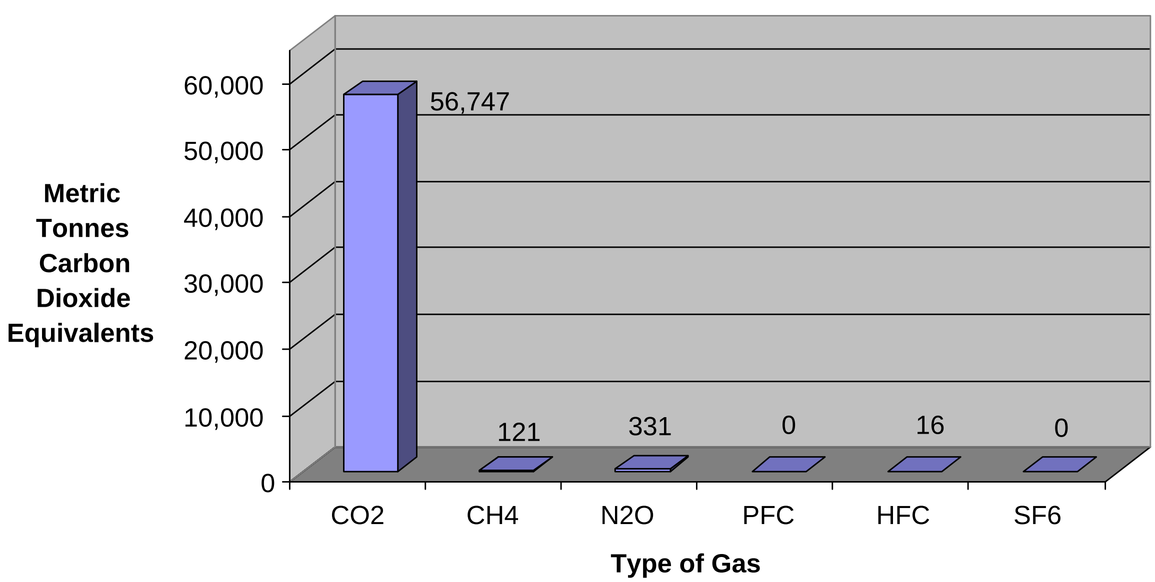


Figure 10: UNH Emissions by Gas (MTCDE) Fiscal Year 2000



Emissions by Source

The sources of the University of New Hampshire's emissions have not changed significantly over the past decade. With the exception of the elimination of the incinerator as a source of heat (in 1996) and growing use of natural gas, there have been few changes in fuel use on the UNH campus. The use of less carbon-intense fuels for production of electricity has also increased slightly. Fiscal Year 2000 provides a representative look at what makes up each of the four sections of the inventory: Energy, Waste, Agriculture, and Refrigeration. Each of these sectors is divided up into smaller categories to provide an in-depth look at the sources of UNH's emissions (Figure 11, Table 5).

Figure 11: Sources of UNH's Emissions, by percent, for Fiscal Year 2000

Total emissions 58,062 MTCDE

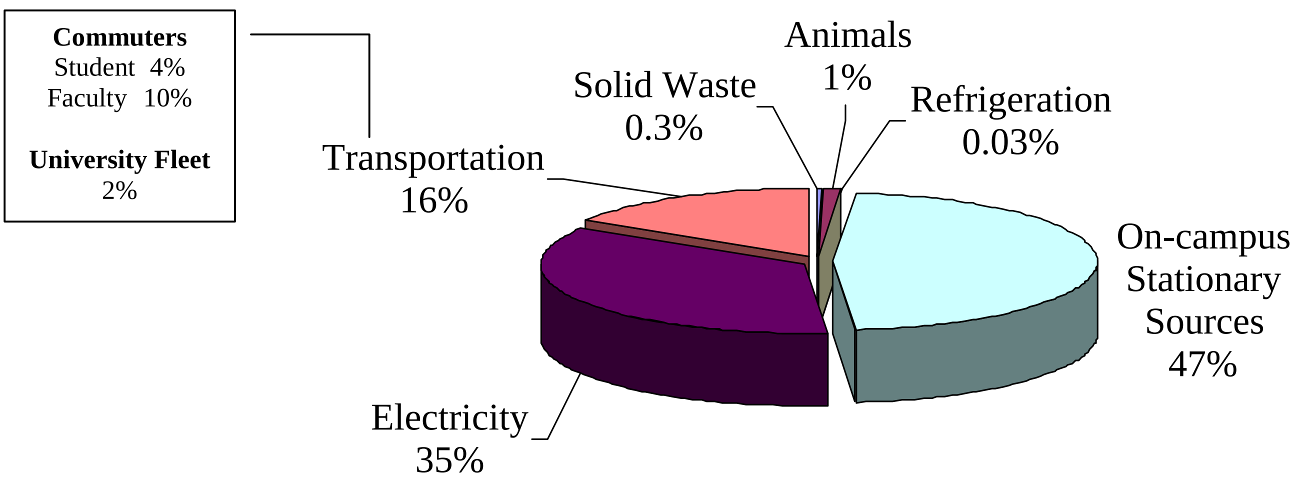


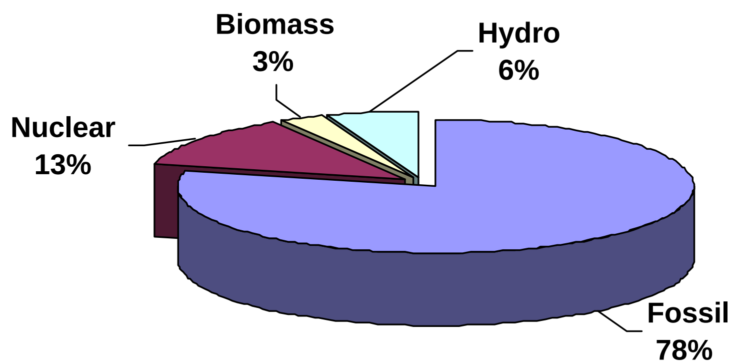
Table 5: UNH's Greenhouse Gas Emissions, by Mass and MTCDE, Fiscal Year 2000

		Energy Consumption TJ	CO_2 Metric Tonnes	CH_4 Kg	N_2O Kg	HFC Kg	Imperial Tons CO_2 Equivalent	Metric Tonnes CO_2 Equivalent
	Solid Waste			9,547			221	200
	Animals			30,750			712	646
	Refrigeration					9	19	17
	On-campus Stationary Sources	394	27,231	3,520	230		30,168	27,376
	Electricity	485	20,361	446	181		22,510	20,426
Transport	**Buses**	6	409	56	10		455	413
	University Fleet	11	742	2	71		845	766
	Commuting Students	35	2,503	539	180		2,832	2,570
	Commuting Faculty/Staff	77	5,501	1,185	395		6,225	5,649
	Total Transport	129	9,155	1,783	656		10,357	9,398
Total		**1.008**	**56.747**	**5.748**	**1.067**	**9**	**63.985**	**58.062**

Part I: Energy

Since the dawn of the industrial age humans have taken advantage of the immense pools of stored energy available as fossil fuels beneath the earth's crust. This source of energy has proven to be relatively inexpensive (when environmental and health costs are externalized) and abundant in quantity, but its use has not been benign. In addition to numerous air pollutants such as lead and carbon monoxide, fossil fuels are the greatest source of human-induced greenhouse gases in this country[18]. At UNH, 78% of the energy consumed is produced with fossil fuels (Figure 12).

Figure 12: UNH's Energy sources, Fiscal year 2000.



Data includes on-campus emissions, sources of UNH's electricity, and commuter traffic. "Hydro" refers to hydroelectric power production in the US and Canada. "Fossil" includes fuel oil, gasoline, diesel, propane, natural gas, and coal. "Biomass" is mostly wood burned for electric production, but also includes some solid waste incineration. Biomass and hydroelectric power production (9%) are the only "renewable" energy sources used.

Combustion of fossil fuels releases relatively small amounts of methane and nitrous oxide and large amounts of carbon dioxide. Carbon dioxide is released when the carbon present in the fossil fuel is atomized and combines with oxygen to form carbon dioxide, water, and carbon monoxide. Thus the mass of gas created is greater than the amount of fuel burned. For example, the combustion of one gallon of motor gasoline, which has a mass of 2.8 kg (6.3 lbs.) releases 8.4 kg (18.5 lbs.) of carbon dioxide[19]. The carbon content of fuels varies greatly (Table 6). For example, the incinerator released nearly twice as much carbon as natural gas. Emissions are therefore dependent on the type of fuel and the efficiency of combustion.

Table 6: Carbon emission coefficients for various fuels burned on campus[20]

Fuel	Metric Tonnes Carbon / MMBtu
Residual Fuel Oil (#6)	0.02149
Distillate Fuel Oil (#2)	0.01995
Natural Gas	0.01447
Propane	0.01699
Incinerator	0.02712

[18] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 1998*, 2000 U.S. E.P.A. http://www.epa.gov/globalwarming/publications/emissions/us2000/executive_summary.pdf

[19] *Annual emissions and Fuel Consumption for an "Average" Light Truck*, US EPA, 1997 http://www.epa.gov/otaq/consumer/ann-emit.pdf

[20] Emission coefficients from *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-1998*, 2000, HTTP://www.epa.gov/globalwarming/publications/emissions/us2000/index.html, incinerator factor *from Compilation of Air Pollutant Emission Factors*, AP-42, 5th Edition, Vol. 1, (http://www.epa.gov/ttn/chief/ap42) For a full explanation of the emission factors, see the appendix.

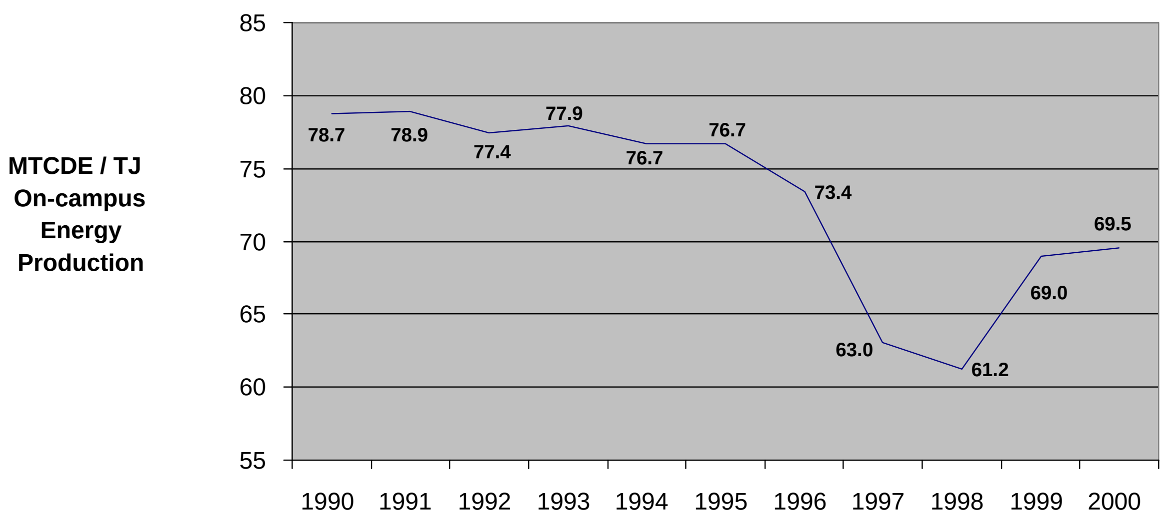
Emissions from the production of energy at UNH has been divided into four categories: On-campus stationary sources, electricity production off-campus, University fleet fuel consumption, and fuel consumption from commuting faculty/staff and students.

On-Campus Stationary Sources

The University utilizes several fuels that are used primarily to generate heat. Number 6 fuel oil and natural gas are burned at the Central Heating Plant to produce steam and hot water. The steam and hot water are then distributed throughout the core campus to heat buildings and provide "domestic hot water" at sinks and showers. Using "absorption" technology, UNH uses steam to provide summer air conditioning at Rudman Hall. Number 2 fuel oil is burned at outlying buildings that are not connected to the central heating system, such as the Gables. Number 2 oil is more expensive than number 6 oil, but it is cleaner burning and more suited to smaller furnaces and boilers. Propane and natural gas, which are cleaner burning than oil, are used for cooking, domestic hot water, clothes dryers, and laboratory experiments. Philbrook Dining Hall, Ocean Engineering, and the Printing and Mail Services Building are heated with natural gas.[21]

The UNH Energy Office has been working on more than 30 energy efficiency projects in the past decade that have helped keep emissions relatively steady despite increasing demand. These projects include lighting retrofits, heating controls, and replacement of outdated equipment, as well as a transition to cleaner burning fuels. The incinerator was phased out in 1996 while natural gas was used for the first time. As a result of these recent projects, over 4,500 metric tons of carbon dioxide emissions (which would have been about 7% of total emissions) are avoided annually[21]. These projects also save the university an estimated $4 million in academic year 2000-2001 from decreased energy consumption[22]. For example, Oak Ridge National Laboratory recently identified UNH's Building Automation System controls, and the ways that they are aggressively used, as the primary reason for our high energy efficiency. In addition, due to these projects there has been a net decrease in emissions per energy unit, though this figure has recently increased (Figure 13).

Figure 13: MTCDE Emissions per TJ On-campus Energy Production



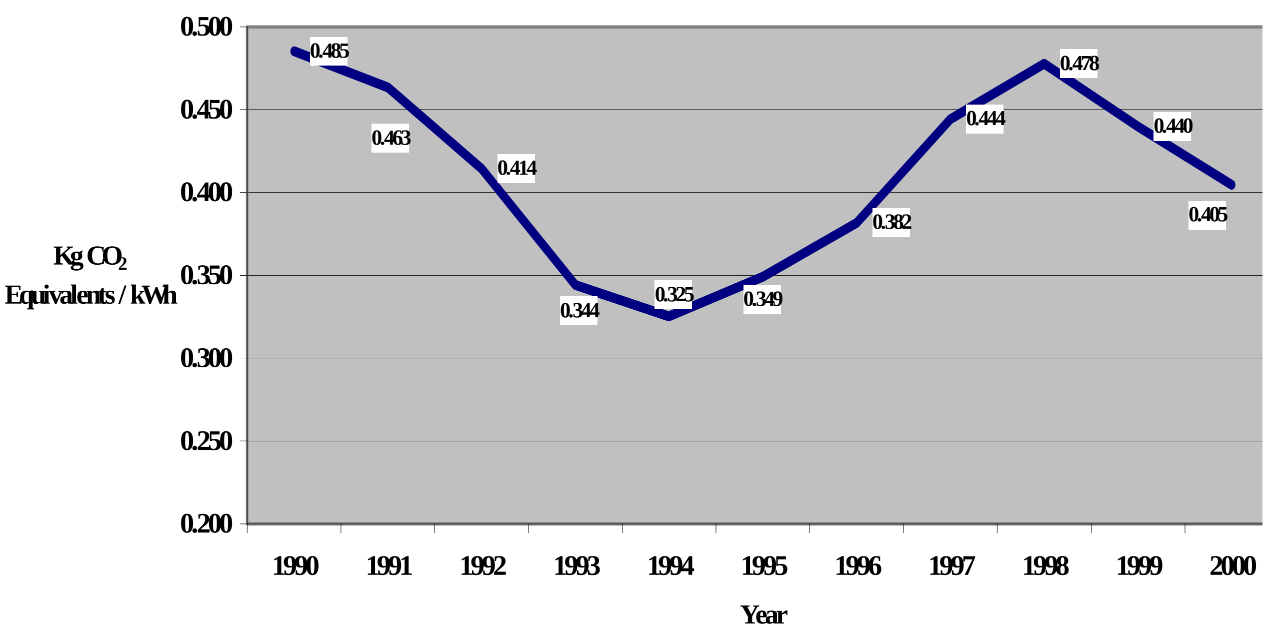
[21] UNH Energy Office, http://www.energy.unh.edu

Electricity

UNH uses electricity for air conditioning, office equipment, lights, elevators, etc. Electricity is also used to heat Williamson, Christensen, Hubbard, Babcock, and Stoke Halls. UNH purchases electricity from The Public Service of New Hampshire (PSNH)[23]. The sources of UNH's electricity for each year were gathered from the Independent Service Operators of New England (ISO-NE) annual reports. ISO-NE is the organization that coordinates the 330 generating facilities in New England[24]. The emissions associated with the production of the electricity consumed were calculated by estimating the amount of each fuel type used to produce the electricity. This estimation includes the efficiency of electricity production for each source, which is only about 35% (meaning about two-thirds of energy created is wasted in electric production). The emissions from the production of electricity were included in the inventory even though they were produced off campus because UNH purchased the electricity and are therefore responsible for the emissions. UNH produces small amounts of electricity, but since it is produced with the #6 fuel oil and natural gas accounted for in the "On-Campus Stationary Sources" section, it will not be included here. UNH also produces small amounts of electricity with Solar Panels mounted on the roof of the Memorial Union Building. Electric production from "Other," which refers primarily to Biomass were not included in the inventory[25].

There have been significant shifts in the type of energy being used to produce the electricity UNH purchases. Due to differing amounts of carbon in each fuel, these variations result in shifts in emissions per kilowatt-hour (Figure 14).

Figure 14: Kg CO_2 Equivalent Emissions per Kilowatt-hour of Electricity



The dip from 1992 to 1995 is due to a temporary increase in nuclear production, while the overall decrease is from a shift to more hydroelectric, natural gas, and biomass.

---

[22] Report from the US Department of Energy Oak Ridge Lab, data provided by the UNH Energy Office http://eber.ed.ornl.gov/commercialproducts/CCAS9798.htm. UNH does not appear in the official report as UNH was analyzed independently by the DOE per Jim Dombrosk's (UNH Energy Manager) request.

[23] Public Service of New Hampshire, http://www.psnh.com

[24] ISO-NE 1998-1999 *Annual Reports*, http://www.iso-ne.com/about_the_iso/

University Fleet

The University is the largest single, non-military employer and fleet operator in the seacoast region. UNH owns and maintains about 270 vehicles, all but a handful of which burn gasoline or diesel fuel[26]. These vehicles, including heavy-duty 35 passenger buses, shuttles, maintenance, and departmental vehicles are usually fueled at the university pumps near West Edge parking lot. These vehicles range in year of production from 1984 through the present and fewer than ten of them use a fuel other than gasoline or diesel fuel.

UNH's bus service, Wildcat Transit, serves the university and general public community of the Seacoast by providing fixed route, public intercity transit between Durham and the Communities of Portsmouth, Newington, Madbury, Dover and Newmarket. Total Ridership in FY 2000 is estimated at 125,000 trips averaging 12 miles per passenger trip. This represents a savings of over 1,500,000 single occupancy vehicle trips in the Seacoast region. The Campus shuttle serves the immediate UNH campus and adjacent lots with high frequency service. In general, there is an active fleet of seven vehicles running 5 days a week. Total Ridership in FY 2000 is estimated at over 525,000 trips and has been growing rapidly as the University expands and develops peripheral facilities.[23]

This study includes the fuel from these pumps but does not include any fuel obtained from other sources. The decreasing apparent fuel consumption of the gasoline fleet is due primarily to the recent trend to reduce fleet size and depend more on rental vehicles for fleet needs (i.e. rather than keeping vehicles on hand for departmental use, departments now often rent from Merchant's Rentals). Distribution of motor vehicle fuel is handled by the state and neither UNH nor the state keep good records of the amount of fuel that is used. The data used was collected from University Vehicle reports from 1994-1998 that listed the fuel used by each vehicle (compiled by a staff position that was eliminated in 1998). Due to this lack of data, years 1990-1993 were assumed to be the same as 1994. Years 1999-2000 were estimated from a linear regression of 1994-1998, assuming that the trend described above (decreasing fleet size) has continued to the present. This means that there could be some error in the estimation of fuel used by the fleet for these years. In addition to this source of error, there were also significant discrepancies between different information sources for fuel consumption. Another report, generated by the UNH Facilities Business Office[27], estimated fuel consumption at over twice the amount of the reports generated by the Transportation Department. The UNH Transportation Department is unable to account for the discrepancy.

The reports generated by the UNH Transportation Department were used in this inventory, with estimated university fleet fuel consumption accounting for about 2% of total emissions (Table 2). However, if the higher estimates were used, fleet fuel consumption would account for about twice that amount.

University Community Commuters

Commuter habits of faculty, staff, and students were estimated to approximate the quantity of fuel burned in transportation from home to UNH and UNH to home. Commuter habits were estimated from a survey completed in May of 2001 by the UNH Survey Center. This information was used to estimate total miles traveled by faculty/staff and students for each academic year and summer months. It was

---

[25] See the text box on Page 17 entitled, "CO_2 Emissions from Biogenic Sources"

[26] *Fleet characteristics - FY 2000 Summary Data*, Steve Pesci, Assistant Director of Strafford Regional Planning Commission, http://www.strafford.org

[27] This report was based on a file sent from the NH Department of Transportation, 603.271.2056

assumed that commuter habits and fuel efficiency have not changed over time, so the fuel use reported in this inventory is directly correlated to the size of the university community.

The survey found that 98.8 % of all faculty and staff drive an average of 4.82 days a week[28]. The average round trip commute for faculty is 27 miles[29]. An average of 36% of students drive to UNH 3.18 times per week. The round trip average for students was estimated to be 12 miles[30].

The estimation of the university community's daily commute is the section with the greatest uncertainty. The survey used to approximate habits was asked of 400 students (3.3% of all students) and 400 faculty/staff (16% of all personnel). The emissions from this section add up to over 10% of the total UNH emissions; this estimation could be in error by several percent.

Part II: Waste Management

As do virtually all communities in our country, UNH produces thousands of tons of solid and liquid waste a year. In the past the solid waste was incinerated in an on-campus facility, but since 1996 it has been landfilled. Our wastewater is processed with the wastewater from the town of Durham. The waste management section of this inventory is divided into these two categories: Solid Waste Disposal and Wastewater Treatment.

Solid Waste Disposal

Methane and carbon dioxide are produced from the anaerobic decomposition of organic waste in landfills by methanogenic bacteria. Only methane is accounted for in this section with the assumption that the CO_2 originates from biomass materials that will be regrown on an annual basis[31].

Three methods of solid waste management have been employed by UNH over the past decade, incineration, landfilling, and composting. UNH incinerated its waste in an independently run on-campus incinerator through 1996. The greenhouse gas emissions from this process are difficult to estimate, as they are highly dependent on the make-up of the waste and were never monitored. The emission factor used is based on an EPA report and was adjusted for the efficiency of the UNH incinerator[32]. Since 1996 UNH has contracted Waste Management[33] to manage solid waste disposal. The waste is trucked to Turnkey Landfill[34] in Rochester, NH, which utilizes electric generation from recovered methane. The emissions from this combustion are not included in this inventory, only the uncaptured methane is included, following the US EPA guidelines [35]. The emissions from the transport of the waste are also estimated (Table 2). UNH also recently began a program to compost food waste from Huddleston Dining hall and the Memorial Student Union (MUB). Any methane emissions from this operation are insignificant.

---

[28] This figure includes carpooling, which is counted as 1/2 trip. Personnel Communication, Andrew Smith, UNH Survey Center, andrew.smith@unh.edu, http://www.unh.edu/survey-center/index.html

[29] Estimation from records received from the UNH Human Resources Department, Toni Searles, Human Resources, UNH, 603.862.0516

[30] It was assumed that most off campus students live within 6 miles of Durham, which includes, Lee, Dover, Newmarket and others.

[31] *New Hampshire 1993 Greenhouse Gas Emissions Inventory*, NH DES, 1997 (http://www.des.state.nh.us/ard/ghgi)

[32] *Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste*, US EPA, 1998, www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf

[33] Waste Management, phone: 713.512.6200 http://www.wastemanagement.com/

[34] Turnkey Landfill, phone: 603.330.0217

[35] See the text box on Page 17, "CO_2 Emissions from Biogenic Sources"

Wastewater Disposal

All of UNH's wastewater goes to the Durham wastewater treatment plant is treated aerobically before being released. Aerobic treatment does not release any methane, and so UNH's wastewater is not included in the inventory[36].

Part III: Agriculture

Animals

As a land-grant university, UNH maintains sizable animal herds. Some domesticated animals, most notably pigs and cows, produce methane as a normal byproduct of digestion, which is known as enteric fermentation. These animals utilize bacteria to assist in the digestion of their food which release methane in the fermentation process[37]. Although there are wild ruminant animals, only the domesticated animals on campus were included in this inventory. Methane is also released from the decomposition of animal waste. There were no perfect records of herd sizes back to 1990, and herd size fluctuates throughout the year, so counts are estimates. Since animal emissions account for only about 1% of UNH's total emissions, the year to year variability for university wide emission estimates are insignificant (Table 2).

Soils Management (Fertilization)

Nitrous Oxide is produced from bacterial denitrification and nitrification, and fertilizing fields increases the amount of N_2O released. However, due to UNH's small amount of farmed land and the relatively low emission factors, emissions would have been well below 1% of the total emissions and were therefore ignored in this inventory.

Part IV: Refrigerants and Other Chemicals

Hydrofluorocarbons (HFCs) are used primarily as alternatives to ozone-depleting substances, such as Clorofluorocarbons (CFCs), that are being phased out under the terms of the Montreal Protocoland Clean Air Act Amendments of 1990[38]. These substances (CFCs and HFCs), are both used at UNH in refrigeration and air conditioning units and are long-lived and active greenhouse gases (Table 1).[39]. Since CFCs are monitored and are being phased out by the Montreal Protocol they are not included in greenhouse gas emission inventories. UNH is required by the US EPA to record the amount of these refrigerants that are lost during the normal recharging of the refrigeration unit and any mechanical failures (leaks) that occur. Unfortunately, these records are only available for 1995-2000, but this will not affect this inventory, as UNH did not begin using HFCs until 1997. Since even the year with the greatest emissions accounts for less than 1% of the UNH total, HFCs are not a significant source of greenhouse gas emissions (Table 2). We have tallied CFC emissions, but following the guidelines of the IPCC and US EPA, they were not included in the inventory (Table 7). If they had been included, CFC emissions would account for as much as 2% of total greenhouse gas emissions (in 1999). To our knowledge, UNH does not use any PFCs or SF_6 on campus.

---

[36] Personal. Communication Clara Reed, Durham Wastewater Plant, 603.868.2274 http://www.ci.durham.nh.us/html/pw9.htm

[37] *New Hampshire 1993 Greenhouse Gas Emissions Inventory,* NH DES, 1997 (http://www.des.state.nh.us/ard/ghgi)

[38] United Nations Environment Program, *Handbook for the International Treaties for the Protection of the Ozone Layer,* 5th Version 2000, http://194.51.235.137/ozat/protocol/main.html
US EPA, Clean Air Act, http://www.epa.gov/oar/caa/contents.html

[39] *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 1998,* 2000 U.S. E.P.A. http://www.epa.gov/globalwarming/publications/emissions/us2000/executive_summary.pdf

Table 7: Emissions of CFCs used at UNH, 1990-2000								
Fiscal Year	CFC-11		CFC-12		CFC-113		CFC-502	**Total Emissions**
	GWP=3,800		GWP=8,100		GWP=4,800		GWP Unknown	**From CFCs**
	kg	MTCDE	kg	MTCDE	kg	MTCDE	kg	MTCDE
1995	0	0	301	1,145	0	0	40	1,145
1996	0	0	359	1,363	0	0	15	1,363
1997	0	0	62	234	0	0	0	234
1998	0	0	73	276	0	0	585	276
1999	440	1,672	92	351	0	0	134	2,023
2000	0	0	48	184	0	0	7	184

Emissions and GWP for CFCs are included for reference only, they are not included in the inventory following the protocol of the IPCC. Records were only available from after 1995, there were likely additional CFC emissions prior to 1995 that are not documented here. All emissions were the result of mechanical failure or mistakes -- there were no intentional releases. No PFCs have been used at UNH. Source: Susanne Bennet, Director of Plant Maintenance, suzanne.bennet@unh.edu.

Conclusion

The UNH Energy Office should be commended for keeping emissions relatively steady over the past decade. Despite a growing population of faculty, staff, and students, greenhouse gas emissions have not increased. This is primarily due to a shift from carbon intensive energy production such as the incinerator, to natural gas on campus. The energy efficiency projects of the Energy Office have also played a major role. The 4,500 metric tonnes of carbon dioxide emissions avoided annually would have accounted for over 7% of the total emissions. If it weren't for the careful management of UNH's energy systems by the Energy Office, it is likely that total emissions would have reflected the growing population and appetite for energy of the UNH Community. In the spring of 2001, the U.S. Department of Energy’s Oak Ridge National Laboratory[40] released a first-of-its-kind energy efficiency benchmarking study of 180 colleges and universities. In its peer group, UNH was placed in the top five percent for energy efficiency. According to the report, if UNH consumed energy at the mean rate for its peer group, total on-campus production and electric consumption would have cost about $10 million for fiscal year 2000. However, due to ongoing energy efficiency programs, UNH spent only $6 million during that time period. So, in addition to reducing potential emissions, these projects save the University an estimated $4 million a year.

The fuels used to produce our electricity (although UNH has no direct control over them) have also shifted to less carbon intensive fuels like natural gas, biomass, hydroelectric, and nuclear. This shift should not put UNH completely at ease, however, for despite miniscule greenhouse gas emissions, these fuel sources are not harmless. The problem and safety of nuclear waste disposal are far from being solved and the flooding of huge tracts of land for hydropower create environmental and social problems we are just beginning to understand.

Despite UNH's work to reduce emissions, UNH's is still a significant source of greenhouse gases. UNH's emissions are about 0.4% of New Hampshire's total greenhouse gas emissions[41]. To put our

[40] Oak Ridge National Laboratory (ORNL) conducts basic and applied research and development to create scientific knowledge and technological solutions that strengthen the nation's leadership in key areas of science; increase the availability of clean, abundant energy; restore and protect the environment; and contribute to national security. http://www.ornl.gov/

[41] *New Hampshire 1993 Greenhouse Gas Emissions Inventory*, NH DES, 1997 (http://www.des.state.nh.us/ard/ghgi/appendix.pdf)

consumption in a global perspective, UNH emits nearly a third of the emissions of the country of Bhutan, which has a population of 2,000,000[42].

UNH electric use has increased 15% over the decade, while on-campus energy production has increased 3.5%. This increase has surpassed the increasing size of the student body, as there has been a 2.3% increase in energy use per student. However, energy use per square foot has decreased 15% from 213 kBtu per SF in 1989 to 181 kBtu per SF in 2000. Despite the great work of the UNH Energy Office, it is clear that UNH is following the national trend towards more energy intensive operations and therefore unlikely that UNH's emissions will continue to decrease without continued conscious decisions and management plans.

Projections

Developing emission projections is a difficult task. The anticipated plans for growth of students and faculty/staff must be taken into account, as well as where people live (such as the plans for a new residence hall), and any possible changes to energy production methods and policies aimed at reducing consumption. This inventory offers only a simplistic projection based on the emissions for the past decade and for the past four years.

If the average net change in emissions per year for the decade (+0.1%) would continue, the university's emissions would be 1.2% higher than 1990 levels by 2012. If the annual average net change in emissions per year for the past 4 years (-2.3% per year) would continue, the university's emissions would be 24% lower than 1990 levels by 2012. However, a portion of this decrease is due to changes in electric production over which the university has had no influence.

Comparisons to Other Higher Education Institutions

Though other schools have conducted greenhouse gas emissions inventories, very few have completed an inventory that is as comprehensive as this one. This makes comparing UNH's emissions to other schools difficult, as other methods were used and not as many sources were included. However, the Tufts Climate Initiative, at Tufts University in Boston, has completed an inventory of comparable scope for the years 1990 and 1998, with projections for 2010[43]. Tufts included emissions from their three campuses; Medford, Grafton, and Boston)

Tufts' inventory included CO_2 emissions from electricity, heating, and transportation (university fleet and commuters), CH_4 from animal agriculture, and N_20 from medical use. CH_4 and N_20 emissions from energy use was not included (CH_4 from energy accounts for 0.1% and N_2O from energy accounts for 0.6% of UNH's total weighted emissions). UNH has included other sources that the Tufts Initiative did not include such as refrigerant use and disposal of solid waste (which account for 1.4% of UNH's total weighted emissions). Therefore, although not a perfect correlation, the sources not included in Tufts inventory add up to only about 2% of UNH's total emissions and are comparable. Tufts total emissions in 1990 were recorded as 58,007 MTCDE, while their 1998 emissions were 65,204 MTCDE (Table 7).

Tufts' emissions per student has remained about 30% higher than UNH's during the decade. As Tuft's emissions per student experienced a net increase, UNH's decreased. As is evident in the variation over

---

[42] *Bhutan Annual Energy Report*, US EIA, January 2001, http://www.eia.doe.gov/cabs/bhutan.html

[43] Tufts Climate Initiative, Thomas Gloria, Ph. D., Tufts University, http://www.tufts.edu/tie/tci/

Table 8: Comparison of UNH and Tufts University[1]				
Comparison of Schools	Emissions 1990 MTCDE	Emissions 1998 MTCDE	Emissions intensity 1990 MTCDE / Student	Emissions intensity 1998 MTCDE / Student
UNH	61,776	64,102	5.34	5.25
Tufts University	58,007	65,204	7.52	7.99

Emissions data from this report and Tufts University Climate Initiative, Thomas Gloria, Ph. D., Tufts University, http://www.tufts.edu/tie/tci/ "Student" refers to Full-Time Equivalents students, a part time student is considered 1/2 a student.

the decade in UNH's emissions, Tuft's inventory of only two years does not supply adequate information to fully compare these two schools or make predictions.

Recommendations

UNH has the opportunity to actively reduce greenhouse gas emissions. The work of the UNH Energy Office has shown that emission reduction is not only possible, but can also be advantageous economically. To continue reducing emissions, the following principles should be considered.

UNH energy policy, including the efficiency projects of the energy office have to date been driven largely by economics and technology. However two factors point to the importance of placing UNH energy policy in a broader educational context: first, as noted above, energy use will likely continue to increase without purposeful policies to mitigate that trend that include an explicit community ethic to conserve energy. Second, with the establishment of the its Office of Sustainability Programs in 1997, UNH has committed itself to a university-wide educational goal of ensuring that all of its graduates develop the competence and character to advance sustainability in their civic and professional lives. This educational goal can only be achieved through modeling best practices in its energy policies as well as all other areas of UNH operations, and integrating those practices into the formal curriculum.

OSP's partnership with Clean Air - Cool Planet, which was initiated with this inventory project, is part of a broader Climate Education Initiative developed to address these educational issues. Other collaborators include the Climate Change Research Center (CCRC) of the UNH Institute of Earth, Oceans and Space, the Campus Energy Office, the UNH Transportation Policy Committee, and Facilities Design and Construction. One project of note is a general education course on global environmental change in which students negotiate implementation of the Kyoto Protocol at UNH. Students first interview and then play the role of senior administrators and other UNH decision-makers and then specify policies and practices to achieve reduction. In addition to this general education coursework, the Climate Education Initiative is working to include climate issues in the emerging Masters of Public Health Program and also assisting with regional climate change impact assessment research with the CCRC.

Energy Efficiency of Production and Consumption

UNH should continue to work towards more energy efficient construction, operation, and policy. The Energy Office has done a great job implementing energy efficiency projects, but there are many improvements that can still be made. The university should approach energy decisions keeping in mind not only the economic cost, but also the environmental effects and educational opportunities of efficient energy production and consumption. For example, sustainable construction and design of building renovations and new construction can reduce the amount of energy used in the long term, as well as create more comfortable interior spaces. Also, the university needs to consider the construction of a co-generation power plant that could supply the university with energy efficient heat and electric. This type of plant uses heat produced in electric generation to heat buildings, rather than wasting two-thirds of the generated energy like most power generating facilities. In addition to using less energy, this type of plant would probably produce power less expensively, as much of the cost of electricity covers transmission, not production. With the deregulation of the electric market, UNH may also have the opportunity to support its choice of power production (such as fossil, nuclear, hydroelectric, biomass, solar, wind, or others). UNH should factor the educational and social benefits of cleaner power into the decision of what kind of power to purchase. UNH should also continue and enhance efforts to educate the university community concerning methods of production and social/environmental costs of our energy use. In addition to reducing our environmental footprint, these activities often save money. As previously mentioned, the efficiency projects undertaken by the Energy Office save $4 million a year (compared to similar sized schools) in reduced consumption according to the study completed by the US Department of Energy.

Transportation Demand Management

Transportation accounts for 18% for UNH's emissions and the vast majority of these emissions come from single occupancy automobiles. Therefore, transportation is a significant source of emissions that can be reduced. Transportation Demand Management (TDM) is a tool to maximize mobility while reducing congestion and the resulting pollution. The goals of TDM are to provide more transport options to UNH community members and more access to needed services. TDM includes: campus shuttles and an efficient bus system, car and van pooling, parking management strategies, alternative mode incentive programs, bicycles and pedestrian planning, and housing and scheduling management.

Data Tables

Table 9: UNH Energy Use Summary, By Fuel

Fiscal Year	Purchased Electricity	On Campus Stationary Sources: #6 Fuel Oil (residual oil)	#2 Fuel Oil (distillate oil)	Natural Gas	Propane	Incinerator Steam	Transportation: University Vehicles: Gasoline Fleet	Diesel Fleet	University Buses
	kWh	Gallons	Gallons	MMBtu	Gallons	1000 lbs steam	Gallons	Gallons	Gallons Diesel
1990	43,344,000	1,544,389	224,138	0	75,646	92,432	86,260	15,222	33,027
1991	43,000,000	1,314,642	273,998	0	99,145	93,423	86,260	15,222	33,027
1992	43,518,428	1,613,052	388,894	0	110,775	81,953	86,260	15,222	33,027
1993	44,105,455	1,328,082	368,527	0	292,255	100,611	86,260	15,222	33,027
1994	43,767,261	1,516,882	374,892	0	331,965	82,413	86,260	15,222	33,027
1995	45,033,744	1,325,604	326,077	0	364,016	78,455	79,031	12,167	40,387
1996	51,098,096	2,222,010	406,599	0	527,420	27,885	81,690	14,736	34,380
1997	50,875,573	1,365,888	355,716	196,311	274,507	0	77,033	13,023	33,487
1998	48,903,360	1,197,672	234,946	234,059	84,637	0	71,352	16,477	41,610
1999	49,859,266	1,984,078	174,488	80,327	84,456	0	69,533	15,335	39,658
2000	50,462,168	1,882,100	132,085	66,349	75,281	0	66,352	15,672	40,685

On-campus stationary sources and electric fuel consumption values from UNH Energy Office, Jim Dombrosk 603.862.2345 <Jim.Dombrosk@unh.edu>. **Fleet Fuel Consumption** values for 1990-1993 and 1999-2000 were unavailable. Fuel consumption values for 1990-1993 are assumed to be the same as 1994 values. Values for years 1999-2000 are from a linear regression of years 1994-1998, assuming that the trend to reduce fleet size and mileage has continued to the present. Equations are as follows: [Gasoline Fleet y = -3181.4x + 101343 Diesel Fleet y = 336.6x + 11969 University Buses y = 1026.6x + 29392] Fuel consumption values 1994-1998 from *State of New Hampshire Motor Vehicle Reports*, 1994-1998. The reports are archived at the UNH Garage, Harold Knowles, 603.862.2746. The reports did not differentiate between gasoline and diesel vehicles. It was assumed that all Mid and Heavy weight vehicles used diesel fuel, and all lightweight trucks and cars used gasoline. This assumption was checked with a sample of 20 vehicles and was accurate.

Table 10: Sources of Electric Production by Percent, 1990-2000

Fiscal Year	Hydro-electric	#2 Fuel oil (Distillate Fuel)	Nuclear	Coal	Natural gas	#6 Fuel Oil (Residual Oil)	Other	Non-Hydro Imports
1990	6.4%	1.1%	31.7%	15.4%	5.1%	33.8%	0.0%	6.4%
1991	8.1%	1.1%	32.5%	15.6%	6.4%	31.7%	0.0%	4.6%
1992	10.1%	0.8%	33.2%	16.2%	10.0%	25.8%	2.4%	1.5%
1993	10.9%	0.3%	37.6%	15.9%	12.5%	17.6%	5.2%	0.0%
1994	11.3%	0.2%	38.2%	15.2%	14.2%	14.0%	5.5%	1.3%
1995	11.2%	0.4%	34.0%	15.5%	17.1%	11.3%	5.3%	5.2%
1996	11.8%	0.8%	28.9%	16.2%	17.7%	10.6%	5.3%	8.8%
1997	12.5%	1.8%	20.3%	17.4%	17.3%	15.2%	5.4%	10.2%
1998	12.8%	2.2%	16.0%	16.8%	16.4%	20.8%	5.3%	9.7%
1999	12.7%	1.5%	21.1%	14.4%	15.7%	20.8%	5.2%	8.7%
2000	11.8%	0.6%	25.7%	14.3%	16.4%	16.5%	5.6%	9.1%

Consumption and Sources of UNH's electricity, by year. Consumption values provided by the UNH Energy Office (Jim Dombrosk, 603.862.2345 **Jim.Dombrosk@unh.edu**). Fiscal year values were calculated by averaging the two years involved (i.e. FY 1991 is an average of calendar years 1990 and 1991). This table does not include "pumped storage" as the emissions associated with this source are included in the other sources. The pumped storage electrical generation was removed and new percentages found from the new total generation. "Hydroelectric" includes power generated from hydroelectric plants inside of New England and Hydro-Quebec combined. "Residual oil" includes small amounts of generation from wood in 1989 and 1990. "Other" principally includes generation from wood and refuse and includes a small amount of start-up oil. "Non-Hydro Imports" represents non-hydroelectric purchases from non-NEPOOL sources outside of New England. Those purchases usually occur during peak power use periods when NEPOOL facilities cannot generate all the electricity required by the grid. Hydroelectric imports (Hydro-Quebec) are included in "Hydroelectric." Source: The ISO New England 1998-1999 *Annual Reports* (**http://www.iso-ne.com/about_the_iso/**) and personal communication with Paul Shortley (**pshortely@iso-ne.com**) for Hydro-Quebec import information. 2000 Data from a ISO-NE System Planning Power Source Report. Mark Babula, Supervisor, Power Supply and Reliability, **mbabula@iso-ne.com**

Table 11: Calculation of Miles Traveled by Student Commuters

Fiscal Year	A Fall/Sping Students	B Trips / Day	C Days / Year	D Miles / Trip	E Fall / Spring Miles/Year	F Summer School Students	G Trips / Day	H Days / Year	I Miles / Trip	J Summer Miles/Year	K Total Miles / Year
					E=AxBxCxD					J=FxGxHxI	K=E+J
1990	4,164	0.64	154	12	4,924,562	3,150	1	35	12	1,323,000	6,247,562
1991	4,128	0.64	154	12	4,882,836	3,150	1	35	12	1,323,000	6,205,836
1992	4,275	0.64	154	12	5,055,702	3,150	1	35	12	1,323,000	6,378,702
1993	4,413	0.64	154	12	5,218,776	3,150	1	35	12	1,323,000	6,541,776
1994	4,463	0.64	154	12	5,278,385	3,150	1	35	12	1,323,000	6,601,385
1995	4,506	0.64	154	12	5,329,904	3,150	1	35	12	1,323,000	6,652,904
1996	4,469	0.64	154	12	5,285,623	3,150	1	35	12	1,323,000	6,608,623
1997	4,483	0.64	154	12	5,302,654	3,150	1	35	12	1,323,000	6,625,654
1998	4,395	0.64	154	12	5,198,338	3,150	1	35	12	1,323,000	6,521,338
1999	4,269	0.64	154	12	5,048,464	3,150	1	35	12	1,323,000	6,371,464
2000	4,307	0.64	154	12	5,094,448	3,150	1	35	12	1,323,000	6,417,448

Column A is a total commuting student count (Student data is recorded from the fall of each year, excluding graduate continuing education students and is recorded as Full-time equivalent students, a part time student is considered to be 1/2 student, Toni Taylor, UNH Institutional Research, 603.862.2120) 36% of Students commute in cars to Durham, UNH Transportation Survey, May 2001, UNH Survey Center. Column B: Commuting Students are assumed to drive 0.64 trips from home to school a weekday (3.18 trips a week). UNH Transportation Survey, May 2001. Commuter habits were assumed to not change over time. Column C: Number of days of class/exams counted from 2000/2001 UNH calendar. Column D: Estimated length of roundtrip, average distance from Newmarket and Dover. Column E: Total School year miles traveled. Column F: Total number of summer school students, (Nancy Hamer, Department of Continuing Education, n_hamer@unhf.unh.edu). Column G: Students are assumed to drive one trip from home to school a weekday. Column H: Days per year is average length of four summer school sessions from 2001 summer schedule. Column I: : Estimated length of roundtrip, average distance from Newmarket and Dover. Column J: Total summer school miles traveled. Column K: Total year miles traveled.

Table 12: Calculation of Miles Traveled by Instructional Faculty

Fiscal Year	A Total Commuting Faculty that Drive	B Trips/Day	C Days/Year	D Miles/Trip	E Miles/Year
	98.8% of all Faculty				E=AxDxExF
1990	696	0.96	154	27	2,814,134
1991	699	0.96	154	27	2,826,109
1992	704	0.96	154	27	2,846,068
1993	720	0.96	154	27	2,909,935
1994	727	0.96	154	27	2,937,876
1995	715	0.96	154	27	2,889,976
1996	721	0.96	154	27	2,913,926
1997	728	0.96	154	27	2,941,868
1998	734	0.96	154	27	2,965,818
1999	729	0.96	154	27	2,945,860
2000	720	0.96	154	27	2,909,935

Column A: 98.8% of UNH Full Time Instructonal faculty with benefits, Budgeted and non-budgeted by fulltime equivalent (USNH Factbooks, secton III 89-99 USNH HR Office) 98.8% of Faculty are assumed to drive, UNH Transportation Survey, May 2001, UNH Survey Center. Column B: Personnel are assumed to drive a roundtrip from home to UNH four (4.82) days a week (4.82 trips a week / 5 days a week = 0.96 Trips/day). UNH Transportation Survey, May 2001, UNH Survey Center. Commuter habits were assumed to not change over time. Column C: Days of class/exams counted from 2000-2001 UNH calendar. Column D: Faculty commuting distance calculated from address data (UNH Human Resources, Toni Searles, 603.862.0516) Column E: Total Miles traveled.

Table 10: Calculation of Miles Traveled by Staff

Fiscal Year	A Total Commuting Staff that Drive	B Trips/Day	C Days/Year	D Miles/Trip	E Miles/Year
	98.8% of all staff				E=AxDxExF
1990	1,658	.96	241	27	10,357,140
1991	1,684	.96	241	27	10,517,524
1992	1,659	.96	241	27	10,363,308
1993	1,732	.96	241	27	10,819,788
1994	1,759	.96	241	27	10,986,341
1995	1,775	.96	241	27	11,085,039
1996	1,754	.96	241	27	10,955,498
1997	1,717	.96	241	27	10,727,258
1998	1,694	.96	241	27	10,579,211
1999	1,771	.96	241	27	11,060,364
2000	1,792	.96	241	27	11,196,074

Column A: 98.8% of UNH Full Time PAT and OS Staff with benefits, Budgeted and non-budgeted by fulltime equivalent (USNH Factbooks, secton III 89-99 USNH HR Office) 98.8% of Faculty are assumed to drive, UNH Transportation Survey, May 2001, UNH Survey Center. Column B: Personnel are assumed to drive a roundtrip from home to UNH four (4.82) days a week (4.82 trips a week / 5 days a week = 0.96 Trips/day). UNH Transportation Survey, May 2001, UNH Survey Center. Commuter habits were assumed to not change over time. Column C: (52 weeks / year) x (5 workdays / week) - (14 UNH holidays/year) - (5 sick/personal days) = 241 working days / year. Column D: Faculty commuting distance calculated from address data (UNH Human Resources, Toni Searles, 603.862.0516) Column E: Total Miles

Table 14: UNH Agricultural, Solid Waste and Refrigerant Data

Fiscal Year	Agriculture			Waste	Refrigeration	
	Cows		Market Pigs	Solid Waste Management	HFC-134A Emissions	HFC-404A Emissions
	Dairy Cows	Heifers				
	Head Count	Head Count	Head Count	Metric Tonnes	Kg	Kg
1990	100	125	104	2,015	0	0
1991	100	125	104	1,475	0	0
1992	100	125	104	1,574	0	0
1993	100	125	104	1,531	0	0
1994	100	125	104	1,531	0	0
1995	100	125	105	2,094	0	0
1996	100	125	122	1,751	0	0
1997	100	125	112	1,994	0	0
1998	100	125	99	1,926	6.6	0
1999	100	125	92	2,187	4.4	226.6
2000	100	125	94	1,872	6.6	2.2

Agriculture - Headcount of UNH animal herds for the past decade. Pig Headcount from pre-1995 was unavailable so an average of herd from 1995-2000 was used. Herd size has remained "about the same" over this time period (UNH Pig Farm, Tom Oxford 603.659.2216). Cow headcount is an average herd size from 1990 – 2000. Herd size has remained "fairly constant" over this time period. (UNH Dairy Barn, Tina Savage, 603.862.1027). **Total UNH Solid Waste Produced**. Tonnage includes all UNH waste not recycled except construction waste that was handled by the contractor. Years 1990, 1993-1994 were unavailable, so an average from an internal recycling memo (1 Feb 93) based on years 1980 through 1992 was used. Any small errors due to this lack of data are insignificant, since emissions from more waste than UNH produced was included in the energy section for the years the incinerator was in use. After 1990, an average of 24% of this waste was recycled and is not included as incinerated trash [2,015 - (2,015 x 24%)=1,531] All solid waste was sent to Turnkey Landfill during years 1997-2000 and was not incinerated. The emissions from waste incineration years 1990-1996 are included on in the "On-campus Stationary Sources" Section. Waste tonnage from: Annual Updates, UNH Recycling Office, 603.862.3100. **Refrigerants** - Emissions from UNH refrigerants. Data was available for 1995-2000 only, but this will not affect the inventory, as HFCs were not used on campus until 1997. There were likely additional CFC emissions prior to 1995 that are not documented here. All emissions were the result of mechanical failure or mistakes -- there were no intentional releases. No PFCs have been used at UNH. Source: Susanne Bennet, Director of Plant Maintenance, suzanne.bennet@unh.edu.