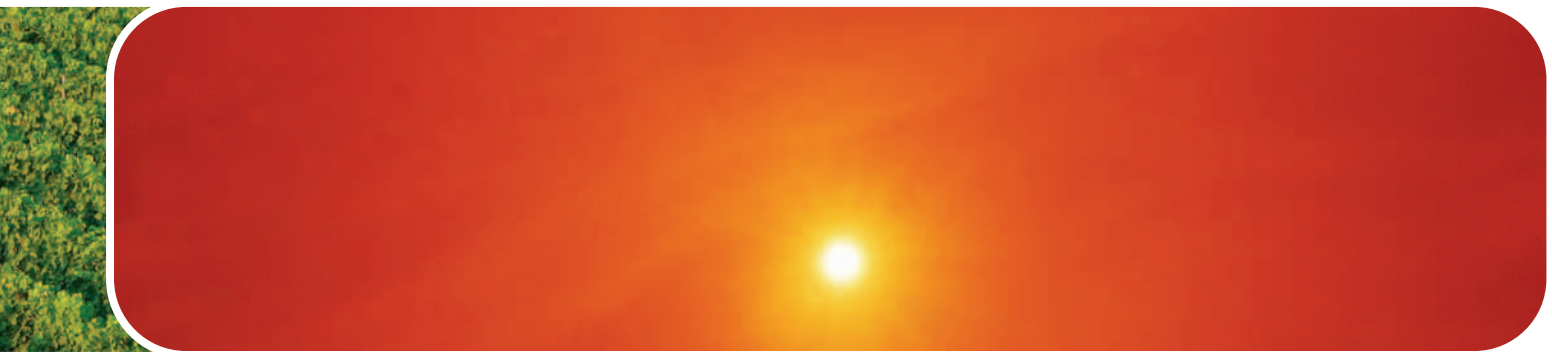
2006

Greenhouse Gas Emissions Inventory 2004-2005 Update

UNH Sustainability Institute

2004-2005 UPDATE

GREENHOUSE GAS EMISSIONS INVENTORY



OFFICE OF SUSTAINABILITY

UNIVERSITY of NEW HAMPSHIRE

2006

A COLLABORATIVE PROJECT BY:

UNH OFFICE OF SUSTAINABILITY
UNH CLIMATE EDUCATION INITIATIVE
CLEAN AIR - COOL PLANET

UNIVERSITY of NEW HAMPSHIRE

September 2006

Dear Colleague:

We are pleased to share with you the University of New Hampshire's 2004—05 Greenhouse Gas Emissions Inventory Update. This update is an important part of our commitment to making UNH a *Climate Protection Campus*.

As a *Climate Protection Campus*, UNH continually strives to increase energy efficiency and cost savings while reducing emissions. Through the work of our Climate Education Initiative and our Energy Task Force, emissions reductions and subsequent improvements in air quality are complemented by related integrative research, interdisciplinary curricula at the undergraduate and graduate levels, and broad-based engagement and outreach programs that educate students, faculty, administrators, staff, and the larger community about the relationships among energy choices, climate, and economic and social well-being.

In addition to continually updating this greenhouse gas emissions inventory, UNH has made major strides towards reducing its greenhouse gas emissions. Ranked in the top five percent of all research universities in its size peer group for energy efficiency by the U.S. Department of Energy, UNH has earned several regional and national awards for its innovative energy conservation efforts. These efforts range from investing in alternative fuels and quieter and cleaner transportation options (the U.S. Environmental Protection Agency designated UNH a "Best Workplace for Commuters" in 2004, 2005, and 2006), to earning the first Energy Star Building rating for residence halls in the nation, to engaging the entire 2006 Freshman class in a university-wide dialogue on Energy. That dialogue will take place against the backdrop of UNH's new combined heat and power facility that is projected to reduce our greenhouse gas emissions by approximately 40 percent.

In the fall of 2005, the UNH Energy Task Force (ETF) was formed. Chaired by UNH Vice President for Research John Aber, the ETF comprises more than 20 student, faculty, and staff members from across the University who are developing and implementing actions to reduce energy costs and emissions, improve energy conservation, and increase faculty, staff, and student awareness of and behaviors around energy use, greenhouse gas emissions, and climate change.

UNH is proud of its regional and national leadership in climate education, energy efficiency, and emissions reductions, and we will continue to build on these efforts in order to expand our leadership as a regional model that integrates the principles and practices of sustainability throughout our curriculum, operations, research, and engagement efforts. To learn more about our commitment to sustainability, please visit www.sustainableunh.unh.edu.

Sincerely,

J. Bonnie Newman
Interim President

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UNIVERSITY of NEW HAMPSHIRE

DURHAM CAMPUS

2004 - 2005 UPDATE
UNH GREENHOUSE GAS EMISSIONS INVENTORY

OFFICE OF SUSTAINABILITY

A COLLABORATIVE PROJECT WITH

UNH CLIMATE EDUCATION INITIATIVE

CLEAN AIR - COOL PLANET

2006

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EXECUTIVE SUMMARY

As a Climate Protection Campus, the University of New Hampshire (UNH) is committed to being a model sustainable community in the state and region. UNH is meeting this commitment through its university-wide Climate Education Initiative (CEI). Overseen by the UNH Office of Sustainability (OS), the CEI is actively engaging the University community in climate change education and greenhouse gas emissions reduction efforts across campus and beyond. Emissions reductions and subsequent improvements in air quality are complemented by related integrative research, interdisciplinary curricula at the undergraduate and graduate levels, and broad-based outreach and engagement programs that educate students, faculty, administrators, staff, and the larger community about the relationships among energy choices, climate, and economic and social well-being.

This report summarizes the greenhouse gas emissions (GHGE) generated by the UNH Durham community from 1990-2005 and, as a supplement to the 1990-2003 UNH Greenhouse Gas Emissions Inventory, extends inventory records through Fiscal Year 2005.[1]

Since 1991, UNH's GHGE have continued to increase with increases in its population and improvements in its infrastructure. Despite a reduction in emissions between 2003 and 2005, there has been a net increase of 25% in GHGE from 1990 to 2005. While the new combined heating and power (CHP, or cogeneration) facility, which comes online in 2006, is expected to reduce UNH's GHGE by approximately 40%, the University historically has averaged an annual increase in GHGE of 1.8%. If UNH continues to follow this trend, then by 2017 it will have fallen out of compliance with not only the international agreement established under the Kyoto Protocol to the United Nations Framework Convention on Climate Change of an 8% reduction in GHGE from 1990 levels, but also with the New England Governors/Eastern Canadian Premiers Climate Action Plan targets, which call for more stringent emissions reductions by 2020.

Further reducing GHGE, including enacting the recommendations in this report, will require creative thinking, innovative solutions, and collaborative efforts. Fortunately, UNH is poised to deal with the challenge that many academic institutions face today: how to address growing energy needs while reducing emissions. Consistent with the University's institutional commitment to being a Climate Protection Campus and to meeting the mission and goals of the CEI, in the fall of 2005 the UNH Energy Task Force (ETF) was formed to develop immediate and future actions that lower energy costs, improve energy conservation, reduce GHGE, and increase awareness of and engagement in behaviors around energy use and climate change. As prior GHGE inventories demonstrate, UNH can and will continue to achieve significant emissions reductions alongside substantial cost savings and educational benefits.

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1 For the 1990-2003 UNH Greenhouse Gas Inventory, visit www.sustainableunh.unh.edu/climate_ed/greenhouse-gas-invnt/1990-2003_UNH_GHG_Report.pdf

University of New Hampshire

UNH Climate Education Initiative

Office of Sustainability

Overseen by the UNH Office of Sustainability (OS), the UNH Climate Education Initiative (CEI) is a university-wide effort to establish UNH as a Climate Protection Campus that integrates the ethics, science, technology, and policies of greenhouse gas reductions into the University's identity and practices. To accomplish this mission, the CEI is actively engaging UNH faculty, staff, and students, along with local, state, regional, and national partners, in greenhouse gas emissions reduction efforts. Emissions reductions and subsequent improvements in air quality are complemented by related integrative research, interdisciplinary curricula at the undergraduate and graduate levels, and broad-based outreach programs that educate the UNH community and beyond about the relationships among energy choices, climate, and economic and social well-being.

Under the CEI, UNH is committed to:

- Reducing carbon dioxide (CO_2) and other greenhouse gas emissions, as well as criteria pollutants as defined by the U.S. Environmental Protection Agency, such as sulfur dioxide (SO_2) and nitrous oxide (N_2O).
- Researching, developing, and demonstrating innovative solutions to energy challenges.
- Researching climate variability, air quality prediction, and public health issues related to climate change.
- Educating students in all fields about the relationships among human activities, climate, health, and appropriate civic and professional actions.
- Continuing to develop the entire University community as a sustainability model for the state and region through integrated policies that link energy, transportation, building design and construction, land use, and sustainable agriculture.

For more information about UNH's Climate Education Initiative,
visit www.sustainableunh.unh.edu/climate_ed/index.html.

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Values derived from www.ofee.gov/recycleld/cal-index.htm and www.ofee.gov/recycled/calculat.htm.

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UNIVERSITY OF NEW HAMPSHIRE 2004 - 2005 GREENHOUSE GAS EMISSIONS INVENTORY UPDATE

INTRODUCTION

Climate is changing throughout New England - with serious consequences. Today, atmospheric carbon dioxide (CO_2) concentrations are at their highest recorded levels in more than 400,000 years.[2] According to the report *Indicators of Climate Change in the Northeast 2005*, the average annual temperature in the northeastern United States has increased by approximately 1.8° Fahrenheit (F) since 1899. In the last 30 years alone, the annual average temperature in the northeast has risen 1.4 F. The greatest warming has occurred during the winter season, with an average annual December to February temperature increase of 4.4 F from 1970 to 2000.[3] It should be of no surprise, then, that New Hampshire and New England are being affected by the resulting changes to the climate system.

Since our climate has continued to change over the course of Earth's history, why should we be concerned now? Over the past century, human activities, primarily from the combustion of fossil fuels, have significantly increased the amount of heat trapping gases in the atmosphere, resulting in CO_2 concentration levels that are nearly as high as were seen when dinosaurs roamed the Earth during the Cretaceous period.[4] This accumulation of gases enhances the Earth's natural greenhouse effect and have led to changes in the Earth's energy balance and therefore to its climate. Evidence of climate change impacts surround us in the form of subtle but clear signals in our landscape:[5]

- Later freezing of lake and river waters in the fall
- Earlier lake and river ice break and water flow in spring
- Reduced average total winter snowfall, especially in northern and coastal areas
- Reduced average number of days with snow on the ground
- More intense precipitation events, defined as more than two inches of water falling in a 48-hour period
- Rising sea levels along coasts
- Rising average annual sea surface temperatures

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2 National Academy of Sciences. (June 2005). *Joint science academies' statement: Global response to climate change*. Washington, DC: http://wwnationalacademies.org/onpi/06072005.pdf.

3 Clean Air – Cool Planet and Wake, Cameron (Climate Change Research Center, University of New Hampshire). (2005). *Indicators of Climate Change in the Northeast 2005*. http://cleanair-coolplanet.org/information/pdf/indicators.pdf.

4 Woods Hole Oceanographic Institution's Ocean and Climate Change Institute. (Posted June 2, 2006.) *Global Warming* Q & A. www.whoi.edu/institutes/occi/viewArticle.do?id=13366.

5 Ibid, 4-27.

While some of these impacts might result in changes that sound good on the surface – such as longer growing seasons or earlier maple sap flows and bloom times for spring plants like apple trees and lilacs – the impact of these changes is more complicated. Climate changes threaten the health of native plant and animal species (including sugar maples, migratory birds, and pollinators), ecosystems, crops, and humans – especially as new species of invasive weeds, pests, and disease-carrying organisms immigrate to New England. No one can predict the future with 100% certainty. But while it is difficult to predict the exact consequences of these climatic change impacts due to year-to-year climate variability and uncertainties in future greenhouse gas emissions (GHGE), it is evident that as GHGE continue to increase, so too will the negative impacts on New England.

The evidence is clear: the ecological, human health, and economic impacts of climate change are significantly affecting our state, region, and entire planet. We can – and must – act now to address the causes and impacts of climate change. But since we are part of the problem, we can be part of the solution. As the primary source of climate change pollution, we can change specific policies and behaviors to reduce our emissions of greenhouse gases and thus lessen our vulnerability to the climatic changes that are taking place now and into the foreseeable future. How we adapt to the changes that have already been set in motion while playing our part to reduce overall GHGE will impact the quality of life in our state and region for generations to come.

UNH's Response to Climate Change

As a Climate Protection Campus, the University of New Hampshire (UNH) is committed to being a model sustainable community in the state and region. UNH is meeting this commitment through its university-wide Climate Education Initiative (CEI).[6] Overseen by the UNH Office of Sustainability, CEI's mission is to integrate the ethics, science, technology, and policies of greenhouse gas reductions into the University's identity and practices. To accomplish this mission, the CEI is actively engaging the University community in climate change education and GHGE reduction efforts across campus and beyond. Emissions reductions and subsequent improvements in air quality are complemented by related integrative research, interdisciplinary curricula at the undergraduate and graduate levels, and broad-based engagement and outreach programs that educate students, faculty, administrators, staff, and the larger community about the relationships among energy choices, climate, and economic and social well-being. Under the CEI, the UNH community is committed to:

- Reducing CO_2 and other greenhouse gas emissions, as well as criteria pollutants as defined by the U.S. Environmental Protection Agency (EPA), such as sulfur dioxide (SO_2) and nitrous oxide (N_2O).
- Reducing potential climate change and thereby improving air quality.
- Researching, developing, and demonstrating innovative solutions to energy challenges.

6 For more information on UNH's Climate Education Initiative, visit www.sustainableunh.unh.edu/climate_ed/index.html.

- Researching climate and air quality prediction and public health issues related to climate change.

- Educating students in all fields about the relationships among human activities, climate, health, and appropriate civic and professional actions.

- Continuing to develop the entire University community as a sustainability model for the state and region through integrated policies that link energy, transportation, building design and construction, land use, and sustainable agriculture.

Demonstrating UNH's institutional commitment to being a Climate Protection Campus and to meeting the goals of the CEI, in the fall of 2005 UNH President Ann Weaver Hart established the UNH Energy Task Force (ETF).[7] Chaired by UNH Vice President for Research and Public Service John Aber, the ETF is comprised of over 20 student, faculty, and staff members from across the University. In particular, the ETF is charged with:

- Developing immediate and future actions to reduce energy costs and improve energy conservation through technological improvements, increases in efficiency, reductions in waste, and selection of fuels at the Durham campus.

- Inventorying and promoting educational and outreach programs intended to increase awareness of and behaviors around energy use, efficiency, greenhouse gas emissions, and climate change.

The work of the ETF not only follows the mission and goals of the CEI but also builds upon UNH's many energy efficiency successes. Recently ranked in the top five percent of all research universities in its size peer group for energy efficiency by the U.S. Department of Energy, UNH has earned several regional and national awards for its innovative energy conservation efforts. These efforts range from investing in alternative fuels and in quieter and cleaner transportation options to earning the first Energy Star Building rating for residence halls in the nation to recycling and composting. UNH is proud of its regional and national leadership in climate education, energy efficiency, and GHGE reductions. This leadership also follows the New England Governors/ Eastern Canadian Premiers Climate Action Plan goals, which have been endorsed by both Democratic and Republican governors in New England, of reducing regional GHGE to 1990 emissions levels by 2010 and by at least 10% below 1990 emissions levels by 2020.

7 For more information on the UNH Energy Task Force, visit www.unh.edu/etf.

2004 - 2005 Update to UNH's Greenhouse Gas Emissions Inventory

This inventory update summarizes the anthropogenic (brought about by human behavior) GHGE generated by UNH from 1990 - 2005 and, as a supplement to the 1990 - 2003 GHGE Inventory report, extends UNH inventory records through Fiscal Year 2005. UNH is committed to updating its GHGE inventory series regularly in order to capture institutional progress in GHGE reductions (such as those stemming from the installation of the new combined heating and power facility, also called the CHP or cogeneration facility) and to inform the community of its on-going efforts related to GHGE reductions.[8] By identifying GHGE sources and quantifying emissions output, UNH's GHGE inventory series help the university establish short- and long-term emissions reduction goals and policies while further advancing educational and research opportunities. In particular, this inventory update also provides recommendations for further reducing GHGE for consideration by the ETF, the UNH Administration, the UNH Board of Trustees, and the entire UNH community.

The UNH GHGE inventory series is adapted from the guidelines of the Intergovernmental Panel on Climate Change (IPCC), a panel of more than 2,000 international scientists organized in 1998 by the World Meteorological Organization and United Nations Environment Programme. Emissions of greenhouse gases are calculated according to their ability to trap heat, which is captured by a specific Global Warming Potential (GWP) for each gas and then reported in conventional units of Metric Tons Carbon Dioxide Equivalents (MTCDE). Since the greenhouse gas CO_2 occurs in the largest concentrations in the atmosphere, MTCDE's indicate the contribution of each greenhouse gas contributing to climate change using the standard of Carbon Dioxide Equivalents (CDE).

For more information on climate change, types of greenhouse gases, their relationship to climate change, and the previous 1990-2003 GHGE Inventory, please visit:

www.sustainableunh.unh.edu/climate_ed/greenhouse-gas-invnt/1990-2003_UNH_GHG_Report.pdf

8 When the 2003 report was published, a CHP facility was approved for construction in an effort to reduce GHGE to a level below 1990 levels and beyond the targets laid out in the Kyoto Protocol. This report will be the last inventory prior to the start of operations for the CHP facility in 2006.

Project Partners

The UNH Office of Sustainability (OS) is an endowed university-wide program charged with working with faculty, staff, students, and a wide variety of local, state, regional, national, and international partners to integrate the principles and practices of sustainability into UNH's curriculum, operations, research, and engagement with the community.[9] UNH's series of GHGE inventories has been developed in collaboration with Clean Air-Cool Planet (CA-CP), an action oriented advocacy group that seeks to reduce the threat of climate change by engaging organizations and institutions in all sectors of civil society. In 2000, OS partnered with CA-CP to develop a GHGE inventory calculator, which was updated in 2003. CA-CP has since distributed the calculator to over 125 campuses throughout the US and Canada, at least 80 of which are actively using it. In the summer of 2005, OS and CA-CP partnered again to update UNH's GHGE inventory through fiscal year 2005 and to improve the calculator (creating version 4.1) and its associated support materials, including an updated user guide and a list of frequently asked questions.[10]

OS would also like to thank all of the UNH colleges, departments, and office who contributed data to this update. Their dedication and enthusiasm help make UNH the model sustainable university and *Climate Protection Campus* it is today and will continue to be in the future.

9 For more information on the Office of Sustainability, visit www.sustainableunh.unh.edu.

10 For more information on the GHGE inventory calculator, visit www.cleanair-coolplanet.org/toolkit/.

OVERALL GREENHOUSE GAS EMISSIONS AND TRENDS

UNH's GHGE are continuing an overall rise that began in 1991. Findings for the 2004 - 2005 period covered by this update show an inter-annual variability caused by a range of factors common to university operations, such as a large building going "offline" for renovation. Specifically, GHGE increased to 72,042 MTCDE in Fiscal Year 2004 (FY04) and then decreased to 68,324 MTCDE in Fiscal Year 2005 (FY05). Overall, inter-annual emissions variability at UNH shows that total GHGE levels were up 10% in Fiscal Year 2003 (FY03), up an additional 4.8% in FY04, and down 5.2% in FY05. Despite a net reduction in emissions from 2003 and 2005, there has been a net increase of 25% in GHGE from 1990 to 2005. UNH has historically averaged annual increases in GHGE of 1.8%.

Another means by which to gauge emissions at UNH is through GHGE per square foot of building space. This metric provides an estimate of the average energy intensity and resulting emissions of buildings. GHGE per square foot (ft^2) of building space decreased in 2005 (after rising from 2002 - 2004), possibly due to renovations to Kingsbury Hall that took the building offline for much of the year, thus reducing its electricity demand (Figure 1). Meanwhile, the area of built space at UNH continues to increase (Figure 1a.) Since 1990, built space at UNH has increased 16% from 3,935,246 ft^2 to 4,562,933 ft^2 in 2005. The current renovations ongoing to Kingsbury Hall are not included in this figure but are expected to increase usable area in the building by 26,000 ft^2.

Figure 1. Emissions per square foot built space at UNH from FY1990-2005 (fiscal). Values shown are represented in units of kilograms of CO_2 equivalents per square foot.

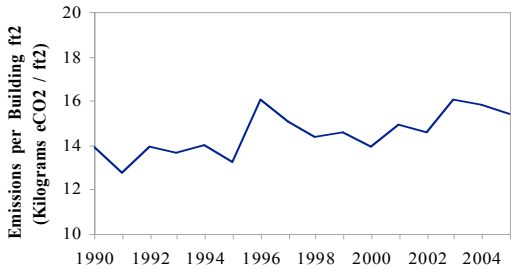
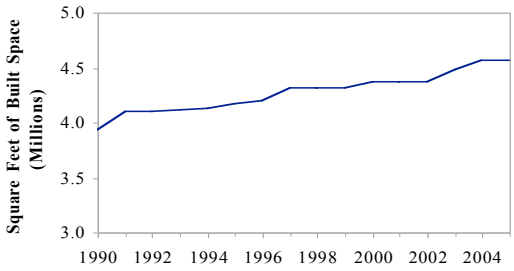
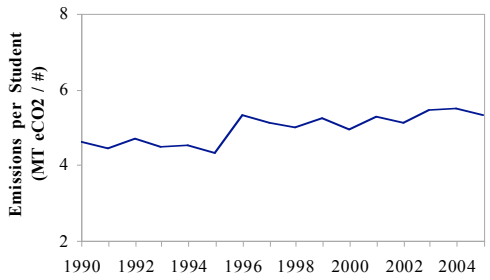


Figure 1a. Built space at UNH in units of millions of square feet from FY1990-2005 (fiscal).



Energy use per student is another GHGE metric. It provides a method by which to compare GHGE of institutions of different sizes and types of infrastructure and can be used in educational efforts to promote student body awareness about climate change. By dividing total institutional GHGE by number of students, per capita energy intensity can be calculated (Figure 2).

Figure 2. Estimated greenhouse gas emissions (in metric tons of carbon dioxide equivalents) per student at UNH 1990-2005. This value assumes students bear sole responsibility for emissions (excluding faculty and staff members) and is intended for sake of comparison given the size of the student body.



While the drop in GHGE in 2005 may have resulted from a reduction in energy use in Kingsbury Hall, as mentioned, it may also be due to a cooler than average summer and warmer than average winter that year, leading to less energy use for cooling and heating. This explanation is supported by a decrease in cooling and heating degree days at UNH. Cooling degree days for the warm season are calculated by subtracting 65 F from the average daily temperature and adding together all cooling degree days. Heating degree days are calculated in the same way except that the differences of mean daily temperatures below 65 F in the cold season are summed. For example, an 80 F day would equal 15 cooling degree days (80 F - 65 F), while a 50 F day would equal 15 heating degree days (50 F - 65 F). Over a one week period of continual 80 F average daily temperatures, there would be 105 cooling degree days (Table 1).

Table 1. Possible explanations for FY05 decrease in greenhouse gas emissions: cooling degree days, heating degree days, and electricity consumption (in kilowatt-hours) associated with renovations at Kingsbury Hall.

Fiscal Year	Cooling Degree Days at UNH	Heating Degree Days at UNH	Electrical use at Kingsbury Hall (kWh)	Equivalent of total UNH electric consumption
2003	712	7290	1,430,578	2.5%
2004	556	6676	761,393	1.3%
2005	504	6754	802,320	1.4%

GHGE levels in FY05 were also lower due to the inclusion of emissions offsets in GHGE calculations. Offsets are emissions "credits" achieved through any practice or process that removes carbon (C) from the atmosphere; they are essentially "negative" GHGE. For instance, composting practices enhance soil C retention and therefore reduce the amount of C available to the atmosphere. Forests absorb atmospheric CO_2 through plant stomatal leaf cells in the process of respiration. Recycling reduces the need for virgin materials that require fossil fuels for processing. Therefore, UNH composting and recycling programs and forest and agricultural land holdings were all applied as offsets beginning in FY03 when composting data became available.

Emissions offsets applied in this inventory, including forest preservation, composting, and recycling, reduced UNH's GHGE total by 1,861 MTCDE in 2005, accounting for 51% of the reduction from FY04 emissions. (Please also see Figure 5 in the "Emissions by Source" section.) The value of forest preservation in sequestering C was calculated according to IPCC protocols. Specific information regarding UNH land holdings was taken from the 2004 UNH Master Plan, which outlines agricultural and forest land owned by UNH. These land areas and their respective C sequestration values were combined to calculate annual C sequestered by lands in UNH possession.

Greenhouse Gas Emissions Targets and Goals

Overall GHGE from UNH, combined with a jump in energy prices in 2005, added a sense of urgency to the CEI's energy efficiency and emission reduction efforts. To meet the internationally established Kyoto Protocol to the United Nations Framework Convention on Climate Change agreement of an 8% reduction in GHGE from 1990 levels, UNH must reduce emissions to 50,306 MTCDE by 2010 (Figure 3). When UNH's combined heat and power (CHP, also called cogeneration) facility begins full operations in 2006, UNH can expect a GHGE reduction of approximately 40%, reducing its overall emissions to approximately 42,300 MTCDE.

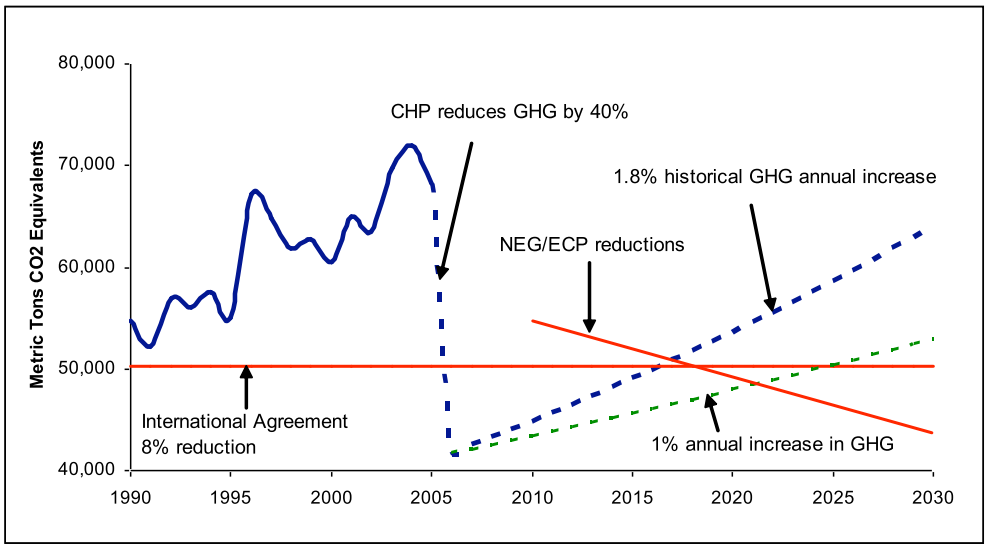


Figure 3. Historical greenhouse gas emissions at UNH and projected combined heat and power facility reductions.

GHGE reductions of 40% assume annual electric load of 64 megawatt-hours (MWh). International Agreement is equivalent to GHGE reductions of 8% (United States) from 1990 emission levels by the year 2010. New England Governors / Eastern Canadian Premiers (NEG/ECP) calls for GHGE levels reduced to 1990 levels in year 2010 and 10% reductions by year 2020 with progressively greater reductions in the years ahead. Projected 1.8% increase in annual GHGE is based on the historical average annual increase in UNH's GHGE.

Financial Findings

Over the past two years, the cost of energy has risen sharply (Figure 4). This increase is the combined result of recent national energy price increases and the regional scarcity of fossil fuel resources. Despite UNH's energy efficiency and GHGE reduction efforts, the UNH energy budget likely will continue to grow. The UNH Office of the President has projected that rising fuel costs have the potential to drive the 2006 university operating budget into a deficit of up to $1 million.

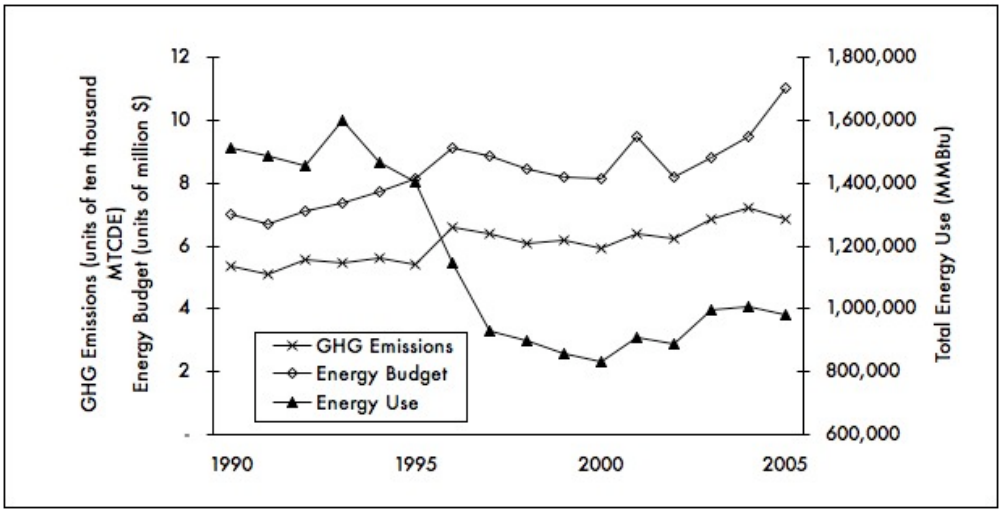


Figure 4. Historical carbon dioxide equivalent emissions, energy budget, and total energy at UNH from FY1990-2005. Units are as described along the y-axes.

Emissions by Type of Gas

UNH continues to emit more CO_2 than any of the other five greenhouse gases identified in this inventory (Table 2). In FY05, actual CO_2 emissions accounted for 98.6% of all GHGE (as measured in MTCDE).[11] Sources of methane (CH_4), the second most prevalent greenhouse gas emitted at UNH, are primarily from agricultural activities and biogenic decomposition of solid waste sent to landfill. Transportation energy use at UNH was the major source of nitrous oxide (N_2O) emissions, the third most prevalent greenhouse gas emitted at UNH.

While this inventory only addresses the emissions of greenhouse gases, the combustion of fossil fuels also results in the production of gases like nitrous oxides (NOx) and sulfur oxides (SOx), which significantly impact human and ecosystem health. Once in the atmosphere, these compounds can be assimilated in water vapor and form acid rain, remain dry particulate matter, or combine with other airborne chemical compounds and particulate matter. NOx can significantly affect human health by creating ground-level ozone and airborne particulates that can trigger serious respiratory problems and heart attacks. NOx and SOx are also the primary components of smog or haze. While haze is a naturally occurring phenomenon, smog is not. Smog can be formed when NOx and SOx react in their gaseous states with water vapor and form much larger water droplets, which have an increased ability to scatter and absorb light and thereby exacerbate the greenhouse effect.

11 See the section "Emissions by Source" for more information regarding UNH's main sources of CO_2 emissions.

Table 2. Emissions by greenhouse gas type at UNH for FY03-FY05. All values are in units of MTCDE.

Gas	2003	2004	2005
Carbon Dioxide (CO_2)	69,024	69,501	67,430
Methane (CH_4)	1,963	1,971	1,970
Nitrous Oxide (N_2O)	554	570	561
Perfluorocarbons (PFC)	0	0	0
Hydrofluorocarbons (HFC)	0	0	224
Sulfur Hexafluoride (SF_6)	0	0	0

Fossil fuel combustion impacts on health-related costs include the following: increased mortality and occurrence of a variety of respiratory ailments; increased hospital admissions; increased cardiovascular symptoms and illnesses; and a possible decrease in resistance to disease, viruses, and bacterial infections. A 2004 report published by the New Hampshire Department of Environmental Services estimated that in 2007 over $1 billion in healthcare-related costs will result from the transport of small particulate matter ($PM_{2.5}$) air pollution and ozone pollution into New Hampshire. The report also identified several impacts on business costs, including increased employee work days lost, increased employee minor restricted activity days, higher insurance costs due to higher claims, lost ability to attract new businesses and jobs due to poor air quality, lost tourism, and higher costs for fuels.[12]

While these findings illustrate the direct links among energy use, GHGE, air quality, and resulting human health, ecosystem health, and financial costs, they also point to the multiple benefits of reducing GHGE. This is a critical point for policy making and is addressed in greater detail in the "Recommendations" section of this report.

Emissions by Source

The majority of UNH's GHGE come from on-campus stationary sources (approximately 50%), followed by purchased electricity (approximately 33%) and transportation (approximately 17%), with refrigerants, solid waste disposal, and agriculture making up less than 2% (Figure 5). Table 3 shows the relative GHGE contribution of each major sector within UNH from 2003-2005. As mentioned, emissions offsets applied in this inventory reduced UNH's GHGE total by 1,861 MTCDE in 2005.[13]

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12 New Hampshire Department of Environmental Services. (May 2004). Air Pollution Transport and How It Affects New Hampshire (R-ARD 04-1). Concord, NH: www.des.state.nh.us/ard/PollutionTransport/.

13 Emissions offsets vary in Figure 5 because recycling data were not available for Fiscal Year 2004. In addition, Fiscal Year 2003 is the first year recycling data was made available for the inventory.

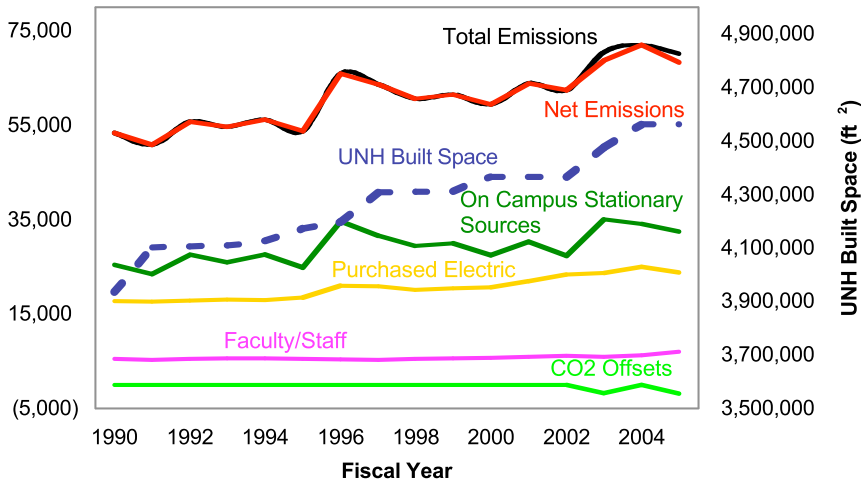

Figure 5. Annual greenhouse emissions produced by major sources at UNH 1990-2005.

Table 3. Percentages of UNH emissions by source from 2003-2005.

Source	2003	2004	2005
On Campus Stationary Sources (%)	50	47	48
Purchased Electric (%)	34	35	35
Transportation: Commuting Faculty/Staff (%)	9	9	10
Transportation: Commuting Students (%)	4	4	4
Transportation: University Fleet (%)	3	3	3
Agriculture (%)	1	1	1
Solid Waste (%)	N/A	N/A	N/A
Total UNH Emissions (in MTCDE)	69,785	72,042	68,324

I. EMISSIONS FROM THE PRODUCTION OF ENERGY

Emissions from the production of energy at UNH are divided into three categories: on-campus stationary sources, electricity production off-campus, and university transportation fuel consumption.

On-Campus Stationary Sources

UNH continues to burn Number 6 fuel oil and natural gas at its central heating plant to produce steam and hot water. Number 2 fuel oil is burned at outlying buildings not connected to the central heating system, such as some farm buildings. When the CHP facility begins operations in 2006, GHGE are expected to decrease by approximately 40% (assuming an annual electric load of 64 megawatt hours). The CHP facility will cut emissions by improving efficiency via capturing waste heat produced in electricity generation to heat and cool buildings, thus avoiding larger waste heat losses typical at utility power plants. As noted in the 1990-2003 GHGE Inventory report, the emissions reductions resulting from the CHP facility will be achieved with existing technology deployed through a financially-sound business model, thereby improving public, environmental, and financial health. What's more, UNH will save $30-40 million (in 2004 dollars) in energy costs over the next 20 years.

Purchased Electricity

UNH uses electricity for air conditioning, office equipment, lights, elevators, and other equipment. Purchased electricity to meet these needs is the second largest contributor of GHGE next to on-campus stationary sources. Electricity for UNH is purchased from the New England pool of energy providers (NEPool), which draws energy from all utilities in New England. NEPool also imports energy from Hydro-Quebec.[14] Hydroelectric facilities produce a significant amount of New England's energy, reaching as high as 10.2% of total Independent System Operators New England Power Pool's (ISO NEPool) electricity supply. Even after the CHP facility begins operations, UNH will still need to purchase 10-20% of its electricity from NEPool.

To date, UNH has taken a number of steps to make buildings on campus more energy efficient, including lighting retrofits and installation of low flow showerheads (Tables 4 and 5).[15] For example, the CEI has developed several initiatives to manage energy demand and reduce emissions, such as WildCAP. Launched in 2005, WildCAP is a campus-wide climate action program that increases energy efficiency and reduces GHGE through education, engagement, and action-based initiatives designed primarily to reach students living on campus.[16] Through WildCAP, UNH students, parents, faculty, and staff, along with community residents, can receive discounts on ENERGY STAR and energy efficient appliances and electronics, such as compact refrigerators and compact microwaves. In addition, the ETF is examining ways to increase energy efficiency and savings while fostering related teaching and research opportunities.

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14 For more information on energy sources for Independent Standard Operators (ISO)-New England, visit www.iso-ne.com/nwsiss/grid_mkts/enrgy_srcs/.

15 For more information, visit http://www.energy.unh.edu/.

16 For more information on WildCAP, visit www.sustainableunh.unh.edu/climate_ed/wildcap/index.html.

Table 4. Partial list of UNH energy efficiency projects through 2001. Approximate annual dollar savings and avoided emissions in pounds are given. Emissions related to electricity savings are based on primary fuel saved at the generating plant (3.2 times the MMBTU (one million BTU) of electricity delivered on site at UNH) and the NEPool 1994 fuel mix.

Project	Dollar Savings	Avoided CO_2	Avoided NO_x	Avoided SO_x
Nesmith Heating Controls	$8,000	369,316	463	792
James Heating Controls	$12,500	584,638	733	1,254
Hamilton-Smith Heating Controls	$16,125	632,386	922	2,282
Hamilton-Smith Lighting Retrofit	$7,500	243,871	510	1,993
NH Hall Heating Controls	$10,391	407,460	562	1,240
NH Hall Lighting Retrofit	$1,750	78,060	163	638
NE Center HVAC Controls	$15,300	1,059,865	1,827	5,854
NE Center Lighting Retrofit	$4,850	787,447	1,647	6,435
Morrill Hall Heating Controls	$5,113	280,315	446	1,282
Stillings HVAC Controls	$1,700	1,297,512	2,502	9,071
Stillings Lighting Retrofit	$7,615	248,202	519	2,028
Dining Commissary Heating Controls	$1,581	65,320	55	194
Dining Commissary Lighting Retrofit	$1,293	39,412	82	322
Field House Lighting Retrofit	$26,000	1,191,907	2,494	9.740
Kendall Hall Lighting Retrofit	$5,600	197,060	412	1,610
McConnell Heating Controls	$3,881	171,993	247	595
McConnell Hall Lighting Retrofit	$4,650	140,004	293	1,144
Horton Heating Controls	$4,500	201,963	269	546
Horton Lighting Retrofit	$3,750	156,468	327	1,279
Paul Arts Lighting Retrofit	$11,500	298,304	624	2,438
Memorial Union Building HVAC Controls	$6,750	262,199	409	1,143
Memorial Union Building Lighting Retrofit	$2,000	62,068	130	507
Parsons Motor Replacement	$7,100	216,412	453	1,768
Parsons Lighting Retrofit	$16,400	446,748	935	3,651
UNHM HVAC Controls	$6,358	149,224	251	837
UNHM Lighting Retrofit	$14,100	333,644	694	2,698
Taylor Heating Controls	$644	33,145	42	74
Taylor Lighting Retrofit	$1,405	37,996	79	310
Campus Exit Sign Replacement	$25,000	684,400	1,432	5,593
TOTAL	$233,356	10,677,339	19,522	57,588

Table 5. Energy efficiency projects in residence halls through 2001. Heating upgrades include installation of insulating steam heat pipes in student rooms and new insulated underground heating mains. Energy conversions refer to converting electric clothes dryers to natural gas dryers.

Residence Hall	Electrical Upgrades (Wiring and Lighting)	Window Upgrades	Heating Upgrades	Energy Conversions	Domestic Hot Water Conversions from Electricity to Natural Gas
Babcock			X	X	X
Christensen			X	X	X
Engelhardt	X		X	X	
Fairchild		X	X	X	
Gibbs	X		X	X	
Hetzel		X	X	X	
Hubbard			X	X	X
Hunter	X		X	X	
Jessie Doe	X	X	X	X	
Lord		X	X	X	
McLaughlin	X		X	X	
Sawyer	X		X	X	
Williamson			X	X	X

Transportation

Transportation accounted for 17.2% of total UNH GHGE in 2005 compared to 15.6% in 2003. This increase was the combined result of several positive and negative factors. Records of vehicle miles traveled indicate an increase of over 200,000 miles logged by UNH transit services in 2005, reflecting a continued growth in public transportation use and offerings, especially into the densest travel routes and off-campus housing areas used by UNH faculty, staff, and students. UNH Transportation Services continues to increase the number of routes and buses made available in order to accommodate a growing population of students, faculty, and staff. Finally, the emissions reductions from other sources at UNH increased the relative importance of emissions from transportation. After the CHP facility comes online in 2006, UNH transportation could rank second to on-campus stationary sources and pull ahead of purchased electricity in terms of overall contribution to GHGE.

However, UNH is already addressing the GHGE stemming from its own transit and non-transit fleet. The University is expanding its fleet of clean technology and alternative fuel transit and non-transit vehicles with the goal of making UNH's overall transportation system one of the cleanest in New England (Table 6). By August 2006, approximately half of University Transportation Services' transit fleet will be "clean fleet" vehicles; of these cleaner vehicles, approximately one-third will be run on alternative fuels. For example, over $2 million worth of low emission diesel transit buses (California Air Resources Board, or CARB, certified) that the University is committed to fueling with biodiesel (B-20) will be added to the transit fleet in the summer of 2006, along with transit and staff vehicles that run on compressed natural gas (CNG). In addition, UNH Facilities and other departments on campus are currently running CNG cars and pickups. With the summer 2006 arrival of several new vehicles, UNH will also expand its fleet of flex-fuel and electric non-transit vehicles. But the University doesn't just invest in alternative fuels and cleaner vehicle technologies. Viewing its entire suite of alternative fuels and clean technology vehicles as moving educational opportunities, UNH is also investing in a new campaign around these vehicles to educate riders, the larger UNH community, grantors, and elected officials about the importance of investing in clean and accessible transportation. As evidenced by this investment, UNH is helping to lead the "clean fleet" charge in the state and beyond.

Table 6. UNH Alternative Fuels and Clean Technology Vehicles Progress as of June 2006.

UNH Combined On-Road Fleet Census (Vehicles)

	Unleaded Gas	Flex-Fuel[1]	Hybrid[1]	Diesel	B20 Transition or Primary	AFV				
						CNG	Electric	Propane	E85[2]	TOTAL
June 30 2004	n/a	1	0	n/a	0	2	0	1	1	4
December 31 2004	n/a	1	0	n/a	0	2	0	1	1	4
June 30 2005	n/a	2	0	n/a	0	8	2	1	1	12
December 31 2005	n/a	2	1	n/a	0	8	3	1	1	13
June 30 2006 est.[3]	n/a	6	1	n/a	6	13	4	1	1	19
Combined UNH and System Fleet	300									
Projected fleet acquisition between now and Dec 31, 2006:										
Ordered (FY 06)	?	4	?		6	4	1	0	0	
Projected through	?	?	?	?	?	?	?	?	?	
	[1] Count non-gas mode again in columns to right									
	[2] Capable but run on UL				Biodiesel Shift when Available					
	[3] Includes those on order				4 excludes trailers					
EPACT CREDIT		*partial*	*partial*	*No*	*partial*	*Yes*	*Yes*	*Yes*	*Yes*	

I. University Fleet

The UNH fleet is divided into transit and non-transit. The transit fleet consists of Wildcat Transit vehicles, Campus Connector vehicles, shuttle route vehicles, access vans, and charter buses, and consumed approximately 40% of UNH fleet fuel consumption in FY05. The non-transit fleet consists of vehicles used for maintenance and facilities, public safety, athletics and recreation, departmental needs (excluding Plant and Animal sciences departmental vehicles like off-road farm equipment), business, and administrative vehicles, and consumed approximately 52% of UNH fleet fuel consumption in FY05. This amount of fuel consumption was higher than all other academic departments. The highest non-transit fuel consumers are UNH Grounds and Roads (8.9% of all university fleet fuel consumed) and UNH Public Safety (5.2%). Plant and animal science departments collectively accounted for approximately 8% of UNH fleet fuel consumption in FY05 (Table 7).

Table 7: UNH Fleet Fuel Consumption FY04-FY05. Data are from July 1 to June 14 for each fiscal year and come from UNH Facilities Business Services Center. CNG data are from a shared meter and based on internal records as assigned 33% transit in FY04 and 80% transit in FY05. All UNH total on-road calculations exclude UNH Animal Science and Plant Science, whose fuel use is predominantly off-road equipment and farm vehicle use. UNH Transit excludes UNH Transportation Services Parking Division Fuel use (which is non-transit).

UNH Fleet Fuel Consumption FY04-FY05								
Fiscal Year	Transit Gallons Diesel &Gas	Transit CNG Therms	Plant & Animal Sciences Gallons Diesel &Gas	Non-Transit Gallons Diesel &Gas	Non-Transit CNG Therms	UNH Total On-Road Gallons Diesel &Gas	UNH Total On-Road CNG Therms	TOTAL
2004	91,961	387	15,687	118,463	787	210,424	1,174	211,598
2005	81,981	15,548	14,292	106,336	3,887	188,317	19,435	207,752
Change	-11%	3918%	-9%	-10%	394%	-11%	1555%	-2%
2006 will herald the introduction of B-20 biodiesel in some transit vehicles and the use of biofuel for some farm vehicles and greenhouses								

In FY04, UNH introduced CNG vehicles to the transit fleet. These vehicles have become increasingly important in improving air quality along transit routes and are part of UNH's Clean Fleet Program. From FY04 to FY05, CNG consumption for the UNH fleet (transit and non-transit) went from approximately 1,200 therms to 19,000 therms as the result of adding six new CNG buses and several new cars and pickups to the CNG fleet. At the same time, UNH fleet consumption of combined gas/diesel fuel fell from approximately 210,000 gallons to 188,000 gallons. The substitution of CNG for gas and diesel fuel resulted in a reduction of approximately 10% of on-road fleet liquid fuel consumption during a year of stable or slightly increasing vehicle miles traveled due to expanded transit service. In addition, this substitution of cleaner CNG reduced UNH's emissions of greenhouse gases, NO_X, and particulate matter.

To date, three grants (from the U.S. Department of Energy, the U.S. Federal Highway Administration's Congestive Mitigation Air Quality grant program, and the U.S. Federal Transit Administration) have provided funding for the installation of a new CNG fuel pump for UNH vehicles. While current pump operations take a slow six hours to fill a 20 gallon tank, the new pump will take only 10 minutes. Construction of the fuel pump should be complete by mid-2006. In 2006-2007, UNH will acquire approximately $2 million worth of a mix of CNG, low emission diesel (2007 standard running up to B-20 biodiesel), and bi-fuel vehicles for both transit and non-transit fleet replacement. UNH has made a commitment to the New Hampshire Department of Transportation (NHDOT) to fuel all its diesel fleet with up to a B-20 blend and has reached agreement for biodiesel to be dispensed from the state-owned fuel station in Durham. Other local users of that station (including Oyster River School District) will have the option of using biodiesel as well.

Continued expansion of the use of CNG by UNH Transportation Services, in combination with the forecasted emission reductions from on-campus stationary sources once the CHP facility becomes active, could significantly reduce overall UNH GHGE in the long term while providing short-term air quality and noise reduction benefits.

II. University Community Commuters

According to a summary of results from a spring 2001 transportation survey performed by the UNH Survey Center, faculty and staff commuters are likely the largest source of transportation-related GHGE. Approximately 7,041 MTCDE were emitted by an estimated 3,294 faculty and staff who commuted to UNH by automobile in FY05 (Table 8).[17] Commuting practices have likely changed over the past four years as a result of increasing fuel prices in the summer and fall of 2005, but updated information will not be available until a new survey has been completed in 2006 and until 2005-2006 transit system ridership data are available. (See the "Recommendations" section for more information.)

Table 8. MTCDE at UNH 2003-2005 by source. Percent change in source emissions from FY03-FY05 is also included.

Source	2003 MTCDE	2004 MTCDE	2005 MTCDE	Change ('03-'05)
On Campus Stationary Sources	35,077	34,115	32,562	-7.2%
Purchased Electric	23,703	25,008	23,811	0.5%
Transportation: Commuting Faculty/ Staff	5,940	6,248	7,041	18.5%
Transportation: Commuting Students	2,732	2,659	2,665	-2.5%
Transportation: University Fleet	2,232	2,147	2,022	-9.4%
Agriculture	955	962	956	0.1%
Solid Waste	N/A	N/A	N/A	N/A

The average distance of a commuting trip and the number of trips per week have the greatest impact on GHGE from commuting. As a result, faculty and staff have the largest impact on GHGE from commuting since they travel farther and more often than students, many of whom live on campus. The 2001 transportation survey found that on average 7% of commuting staff, 4% of commuting faculty, and 2% of commuting students carpool. According to the Bureau of Transportation Statistics (BTS), 8.7% of workers nationwide who rely on automobile transport carpool.[18]

Commuter ridership on UNH Wildcat Transit routes continues to increase (Figure 6, Table 9). The number of bus riders using Wildcat Transit routes 3,4, and 5 (which run to neighboring municipalities) increased by approximately 72% from FY99-FY05. This increase exceeds the

17 Smith, Andrew, PhD. (Spring 2001). 2001 University of New Hampshire Transportation Survey. Durham, NH: The Survey Center at the University of New Hampshire, www.unh.edu/transportation/tpc/docs/apdxC.pdf.

18 www.bts.gov/publications/national_transportation_statistics/2005/html/table_01_38.html

rate of increase in student enrollment but is below the rate of increase in gasoline prices. In FY99, Wildcat Transit ridership effectively removed 437 student cars from the road[19] and prevented the emission of 2.12 MTCDE for that fiscal year.[20] This figure increased by 72% in FY05, the equivalent of removing 754 student cars and preventing the emission of 3.66 MTCDE. What's more, the number of community members using the Campus Connector increased 41% from FY99 through FY05 and 19% from FY03 through FY05. In FY06, ridership on both Wildcat Transit and Campus Connector is projected to be approximately 49% more than FY99 ridership.

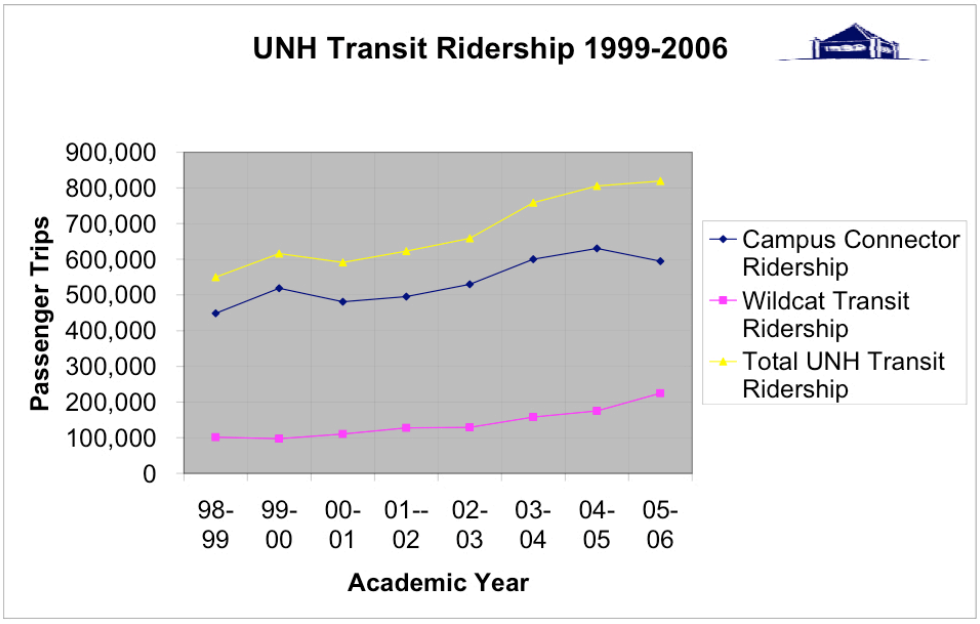


Figure 6. UNH Transit Services ridership trends from 1998 – Projected 2006.

19 The effective removal of cars from the road is calculated by assuming that 85% of riders on Wildcat Transit routes are students, that each student would drive alone to campus if not taking transit, that one transit ride is equal to 0.5 commuter roundtrips to UNH, and that students make 98.56 commuting trips to UNH per year.

20 The MTCDE prevented from being emitted is calculated by assuming that the equivalent automobile commute is 12 miles per trip and that vehicle efficiency is 22.1 mpg.

Table 9. UNH Transit Services ridership numbers from 1998 – Projected 2006.

Total UNH Transit Ridership								
1998-1999	*1999-2000*	*2000-01*	*2001-02*	*2002-03*	*2003-04*	*2004-05*	*2005-2006*	
FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY 06 Proj	
98-99	99-00	00-01	01--02	02-03	03-04	04-05	05-06	Net Change from 99-06
549,856	615,960	591,170	622,920	659,063	758,455	*805,643*	*819,422*	
	12%	*-4%*	*5%*	*6%*	*15%*	*6%*	*2%*	*49%*

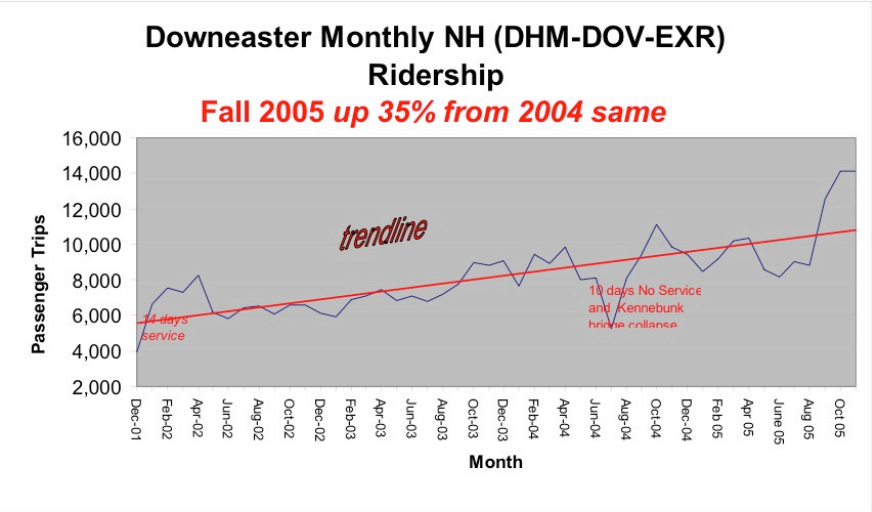
Campus Connector - Combined Routes								
1998-1999	*1999-2000*	*2000-01*	*2001-02*	*2002-03*	*2003-04*	*2004-05*	*2005-2006*	
FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY 06 Proj	
98-99	99-00	00-01	01--02	02-03	03-04	04-05	05-06	Net Change from 99-06
448,444	518,950	480,684	495,166	530,134	600,506	*630,754*	*594,616*	
	16%	*-7%*	*3%*	*7%*	*13%*	*5%*	*-6%*	*33%*

Wildcat Transit - Routes 3, 4,5								
1998-1999	*1999-2000*	*2000-01*	*2001-02*	*2002-03*	*2003-04*	*2004-05*	*2005-2006*	
FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY 06 Proj	
98-99	99-00	00-01	01--02	02-03	03-04	04-05	05-06	Net Change from 99-06
101,412	97,010	110,486	127,754	128,929	157,949	*174,889*	*224,806*	
	-4%	*14%*	*16%*	*1%*	*23%*	*11%*	*29%*	*122%*

III. Train Travel

In 2001, Amtrak Downeaster Passenger Rail service opened a train station on the UNH-Durham campus. Since that time, ridership on the Downeaster during the academic school year has risen from 3,536 riders in the 2001-2002 academic year to 26,936 in the 2004-2005 academic year. In 2005, C&J Trailways bus service entered a partnership with the Downeaster to provide bus service between UNH and Boston's North Station, providing passengers with four daily round trips by rail and one daily round trip by bus.[21] To date, Downeaster ridership continues to grow immensely. In November 2005, Downeaster ridership origination from the UNH-Durham station was 60% greater than ridership in November 2004 (Figure 7).

21 For more information on bus and rail service at the UNH-Durham campus, visit www.cjtrailways.com/service-durham.htm and www.thedowneaster.com/durham.php.



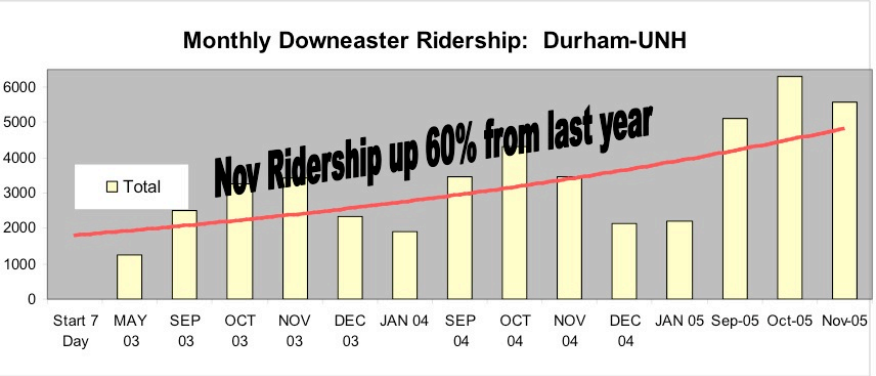


Figure 7. Amtrak Downeaster Passenger Rail ridership trends between 2001 and 2005.

The potential of Downeaster ridership to reduce GHGE is great and predicted to grow. For example, in November 2005, 3,823 one-way trips were made on the Downeaster between Durham, New Hampshire, and Boston, Massachusetts. If we assume that each of these one-way trips represents a different individual who could have driven alone from the UNH-Durham train station to North Station in Boston (approximately 59.1 miles), by taking the

Downeaster instead each individual effectively prevented approximately 91 MTCDE from being emitted and saved $24,332 in gasoline costs.[22]

IV. Air Travel

UNH air travel patterns remain difficult to estimate, and university-wide air travel transportation records and habits were not calculated in this inventory. Most UNH-affiliated business travel requires either a pre-approval or a travel reimbursement form. Although mileage traveled over the course of each trip is required for automobile travel, mileage is not recorded for air travel, even though final destinations are included when trips are approved. Ultimately, travel forms are scanned into the *Liberty* software databank for storage, but access to these records is restricted to only a handful of individuals. Our efforts at obtaining university-affiliated air travel records are ongoing, but the GHGE from air travel are not included in this report.

Due to the large demand for air travel as a method of transportation for UNH related activities, we anticipate that such travel is a significant portion of UNH's GHGE. To illustrate the potentially large contribution of air travel to UNH's annual GHGE, let us assume a hypothetical air travel scenario. If each faculty and staff member of UNH (3,404 in FY05) travels roundtrip from Logan International Airport in Boston, Massachusetts, to Los Angeles International Airport in California at least once per year, the equivalent still air distance (ESAD, the equivalent mileage due to headwinds and tailwinds) would be 19,314,296 miles (5,674 miles times 3,404 individuals). For comparison, faculty and staff estimated automobile commuting miles in FY05 were 17,415,111 miles. This amount of travel would increase GHGE by 8% (assuming FY05 annual emissions) or 5,393 MTCDE. Although not all faculty and staff travel, given that some faculty and staff may fly more than once a year and that some graduate and undergraduate students travel to attend conferences and athletic events, the aforementioned hypothetical travel scenario likely underestimates total UNH air travel mileage. Currently air travel for activities unrelated to university operations, such as vacation travel, are not included in the scope of this inventory.

II. EMISSIONS FROM WASTE MANAGEMENT

UNH produces thousands of tons of solid and liquid waste a year organized into the following waste stream categories: waste sent to landfill, recyclables, food compost, agricultural, electronic, chemical, radioactive, and infectious. The current GHGE inventory calculator applies emission factors developed by the EPA for solid waste sent to landfill and emissions offsets resulting from recycling, composting, and certain agricultural practices.

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22 This estimate assumes the following: that of the 3,823 one-way trips made between Durham, NH, and Boston, MA in November 2005, each trip represents one individual who would driven alone if he or she not taken the train; that a one-way trip between the UNH-Durham train station and North Station in Boston, MA, was made at 59.1 miles; that the average miles per gallon for each of these 3,838 vehicles is 22.1; that the average cost for a gallon of gasoline in New England as of February 6, 2006, is $2.38; and that each gallon of motor gasoline releases 19.564 pounds of CO_2 when burned. Please see www.eia.doe.gov/oiaf/1605/coefficients.html and www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_home_page.html for more information.

Electronic, chemical, radioactive, and infectious wastes are not addressed in this inventory as UNH accounting of these substances does not currently allow for estimates of GHGE.

Landfills are the largest anthropogenic sources of methane (CH_4) emissions in the United States. In 2003, US landfill CH_4 emissions were approximately 24% of total CH_4 emissions, which represented a decline of 24% since 1990.[23] UNH maintains a limited record of its landfill waste stream. Therefore, this inventory estimates university landfill CH_4 emissions from data last provided in 2002, the last year specific reports were made available by the contracted waste removal company. Further issues complicating accurate CH_4 emission estimation involve the quality of waste sent to landfill and the accuracy of the emission factors used in calculations. Specifically, current national estimates of CH_4 emissions are based on municipal solid waste (MSW) data provided to the EPA from numerous sources across the country. These data reflect waste pattern averages from various sources (like universities, offices, high schools, etc.) and do not account for waste reduction practices currently implemented by UNH that reduce CH_4 emissions in landfills, such as recycling corrugated cardboard .

UNH began a program to compost food waste from several locations on campus and in the wider Durham community in 1998. As part of the UNH Food and Society Initiative at OS, the compost program demonstrated a viable and effective alternative to adding food waste to the wastewater stream and the landfill. Since the program's inception, over a half million pounds of food waste have been diverted. In academic year 2004-2005, waste was collected from four campus dining halls (Holloway Commons, Huddleston, Stillings, and Philbrook), Oyster River Middle and High School, UNH research greenhouses, the UNH poultry barn, and a local grocer (the Durham Marketplace). However, any CH_4 emissions offset by this composting operation were negligible (less than 100 MTCDE).

In 2005, UNH recycling programs removed light iron, electronic waste, glass, plastics, and 630 tons of paper from the waste stream. All these efforts resulted in a reduction of approximately 17,000 MTCDE. These efforts to reduce UNH solid waste undoubtedly altered the composition of materials headed to landfill. As a result, it is highly likely that current estimates of UNH's CH_4 emissions from landfills – which are based on national MSW data – are too high.

Even though UNH sends its solid waste to a landfill with CH_4 capture and electric generation facilities, there is a large proportion of CH_4 not recovered in these processes. Based on information last recorded in 2002, CH_4 emissions from landfilled solid waste were 61 tons. However, net CH_4 emissions were less (39 tons) as a result of the CH_4 capture and electric recovery facilities in place at Turnkey landfill. Therefore, estimated CH_4 emissions from solid waste sent to landfill have not changed since 2002.

Currently, UNH employs the waste management services of Clean Harbors Environmental Services (Braintree, MA) for chemical waste disposal, B & G Environmental (Rochester, NH) for spill response management, and Onyx Environmental (Stoughton, MA) for electronic

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23 U.S. EPA. (April 2005). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003 (EPA 430-R-05-003), http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html.

waste (such as batteries and fluorescent lamps) disposal. Additionally, Waste Management of NH now manages the recycling of paper and plastics.

III. EMISSIONS FROM AGRICULTURE

As a land-grant institution that values its agricultural heritage and future, UNH conducts ongoing livestock teaching, research, and outreach that includes cows, pigs, chickens, and horses. These animals produce CH_4 emissions as a normal byproduct of digestion. However, the numbers of animals UNH maintains has remained relatively constant over the last few years with little to no impact on total GHGE for fiscal years 2004 and 2005. The only decrease was in the number of poultry animals under management, and this change did not impact emissions estimates. Future GHGE inventory updates will document any changes in GHGE due to UNH's new organic dairy, which was established in late 2005 and is the first organic dairy at a land grant university in the country.

IV. EMISSIONS FROM REFRIGERANTS

UNH is required by the EPA to record the amounts of any refrigerants that are lost during the normal recharging of refrigeration units and any mechanical failures that occur (i.e., leaks). In FY03, UNH did not have any recorded losses of refrigerants. In fiscal years 2004 and 2005, UNH lost 60 pounds of HCFC-22, a hydrochlorofluorocarbon. This amount was equivalent to 224 MTCDE (less than 0.01% of total GHGE) as HCFC-22 has a very long atmospheric life span. As of December 2005, UNH has not used any perfluorocarbons (PFCs) or sulfur hexafluoride (SF_6) on campus.

MAJOR ACCOMPLISHMENTS AND CHALLENGES

As evidenced by the 1990-2003 Greenhouse Gas Emissions (GHGE) Inventory and this update, UNH is a leader in climate protection and greenhouse gas reductions. The university's campus-wide CEI has actively engaged students, faculty, and staff in climate change education and emissions reduction efforts across campus and beyond, and the formation of the UNH ETF in November 2005 strengthened UNH's institutional commitment to conserving energy, lowering energy costs, and reducing GHGE. Table 10 lists other UNH accomplishments to date and planned next steps in areas related to energy and climate change.[24, 25]

Despite UNH's accomplishments, significant challenges remain if GHGE are to be kept from rising after the new combined heat and power (CHP) facility begins operations in mid-2006. For instance, campus building gross square footage (GSF) has increased at an annual average of 42,000 ft^2 since 1990, while student enrollment has increased at an annual average of 107 students since 1990. The combined effect of these increases presents a clear challenge for UNH: how to address the energy and other resource needs of an expanding population and infrastructure while reducing the GHGE that tends to accompany such growth (Figures 3 and 4). Many of the simplest GHGE reduction strategies in terms of costs, time, and variety of stakeholders involved have already been implemented. Remaining emissions reductions will require a deeper cultural shift that reorients UNH's policies and practices by engaging the entire community in creative thinking, collaborative efforts, and innovative solutions.

UNH is poised to address these challenges, however: UNH's CEI and ETF have already begun a cultural shift that is instilling the University's commitment to being a Climate Protection Campus into its core identity. For example, with its campus-wide membership of students, faculty, administrators, and staff, the ETF has already led a successful "powerdown" campaign over the 2005 Thanksgiving and winter breaks. By shutting down computers and unplugging office and lab equipment over the three-day Thanksgiving break and December/January winter break, faculty, staff, and students saved more than 147,000 kWh, which is equivalent to the amount of energy needed to light approximately 118 U.S. homes for a year. This energy conservation also resulted in over $20,000 in energy costs saved and GHGE prevented equivalent to removing 30 cars from the road for one year. Most importantly, this successful pilot effort brought together faculty, staff, and students from multiple departments around a common, coordinated effort that benefited everyone.

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24 For more information on the UNH Energy Task Force, visit www.unh.edu/etf/successstories.html.

25 The computer power management estimate in Table 10 assumes a typical ENERGY STAR computer monitor low-power sleep mode energy use of 3 watts and an average electricity rate of 13.8 cents/kWh. In addition, it assumes EPA conversion coefficients of 11,560 lb. CO_2/automobile, 1.43 lb. CO2/kWh, and 1,250 kWh/year to light the average U.S. home. See http://pmdb.cadmusdev.com/powermanagement/quickCalc.html#calculatorTop for more information.

Table 10: UNH Energy/Climate Accomplishments to Date and Next Steps

	Accomplishments to Date
Curriculum	Curricula focused on climate change impacts and mitigation, including the following undergraduate and graduate courses: ChE 401 Energy and the Environment; ESCI 405 Global Environmental Change; ESCI 514 Introduction to Climate; ESCI 815 Global Atmospheric Chemistry; ESCI 764/864 Introductory Paleoclimate Analysis; ESCI 862 Paleoclimatology; NR 415 Global Biological Change; and NR 767/867 Earth System Science, among others. In the last five years, over 500 students have taken Global Environmental Change, an interdisciplinary undergraduate course in which students study the relationships among global environmental change, climate, and health, and meet with campus administrators to develop greenhouse gas reduction recommendations.
	Innovative UNH Masters of Public Health Program option entitled "Public Health Ecology ," which educates public health students to address the risks associated with climate change and variability through courses on climate and health (PHP 930 Climate Change and Health) and disease ecology (PHP 932 Disease Ecology).
	Roundtable discussion on how the Northeast is responding to climate change, including through the Regional Greenhouse Gas Initiative, attended by students, faculty, and staff.
Operations	Creation by President Ann Weaver Hart of the UNH Energy Task Force.
	Development with Clean Air Cool Planet of the first greenhouse gas emissions inventory tool for campuses, which is now being used by dozens of universities around the country.
	Online operation of an on-campus combined heat and power (CHP, or cogeneration) facility, reducing the Durham campus's greenhouse gas emissions by approximately 40%. The foresight of the UNH Board of Trustees to approve construction of the CHP facility demonstrates not only UNH's commitment to emissions reduction but also the significant economic benefits to be realized from improving energy efficiency and reducing GHGE.
	Awarding of first U.S. Environmental Protection agency ENERGY STAR rating for residence halls in the country to Congreve, Lord, and McLaughlin.
	Ranking by the U.S. Department of Energy's Oak Ridge National Laboratory (ORNL) in the top 5% of universities in its peer group for energy efficiency.
	Development of a program to compost food waste from several locations on campus and in the wider Durham community in 1998. Since the program's inception, over a half million pounds of food waste have been diverted from the waste stream.
	Implementation by the Transportation Policy Committee of transportation demand management policies designed to reduce single occupancy vehicle trips by providing viable transportation alternatives.
	Addition of 6 compressed natural gas shuttle buses, UNH's first all-electric non-transit vehicle, and over $2 million worth of low emission diesel transit buses to be fueled with biodiesel (B-20) to UNH's fleet of alternative fuels and clean technology vehicles. Also continued growth in transit offerings, especially into the densest travel routes and off-campus housing areas used by UNH faculty, staff, and students
	Designation by U.S. Environmental Protection Agency and U.S. Department of Transportation as a "Best Workplace for Commuters" for third year in a row.
	Completion of infrastructure improvements in buildings across campus, including lighting retrofits and the installation of low-flow water fixtures.
	Powerdown over Thanksgiving and winter breaks resulting in over 147,000 kWh and $20,000 in energy costs saved and greenhouse gas emissions prevented equivalent to removing 30 cars from the road for one year.
	Use of power management in 205 computers in UNH Student Computing Clusters. Combined with using LCD monitors (which typically use 34 watts when active instead of the 73 watts used by CRT monitors) in the computer systems purchased in 2004, in FY05 monitor power management in these clusters saved approximately $10,778 in energy costs and prevented 51 MTCDE from being emitted. This energy savings is the equivalent of taking 10 cars off the road or lighting 62 homes for one year.

	Accomplishments to Date
Research	Research on climate variability, air quality, and related health impacts through the Integrated Human Health and Air Quality Research project (INHALE).
	UNH Biodiesel Group research on wide-scale benefit production from algae.
	Formation of an Ecology, Climate, and Health Working Group linking faculty from diverse departments, including Microbiology, Zoology, Natural Resources, and Public Health, along with the UNH Office of Sustainability, the UNH Climate Change Research Center, the New Hampshire Veterinary Diagnostic Laboratory, the Jackson Estuarine Laboratory, the New Hampshire Department of Health and Human Services, and the New Hampshire Department of Agriculture, to integrate research on ecological health, public health, disease, and climate change.
Engagement	Successful launch in 2005 and second year in 2006 of WildCAP, which offers UNH faculty, staff, students, and parents, along with Durham-area residents and landlords, discounts through local business Houghton's ACE Hardware of Durham, Lee, and Newmarket, New Hampshire, discounts on ENERGY STAR and energy efficient appliances and electronics for residence halls, apartments, and offices.

	Next Steps
Curriculum	Continued growth of curricula focused on climate change impacts and mitigation, including the new Discovery Program Inquiry course POLT 444 Science, Policy and Climate Change" and ENE 797 Sustainable Engineering.
	2006-2007 Discovery Program University Dialogue (annual campus-wide discussions and events) theme of energy.
Operations	First annual UNH Student Energy Waste Watch Challenge in residence halls and on-campus apartments.
	Expanded educational campaigns around computer power management and powerdown.
	Educational material & training for purchase card (p-card) holders to help them purchase ENERGY STAR and energy efficient office equipment and electronics.
	Conversion of dining area waste vegetable oil into biodiesel to fuel off-road farm equipment and to heat greenhouses and other farm buildings.
	Expansion of UNH fleet of clean technology and alternative fuel transit and non-transit vehicles, including institutionalized policies and guidance on vehicle selection (including fuel and emission standards) and an "EcoCAT" branding and educational campaign.
	Renovation of James Hall into a more sustainable building that will serve as a campus-wide model for other renovation and construction projects.
	Continued lighting retrofits and upgrades, along with other energy efficiency improvements in buildings on campus.
	Use of recaptured methane from Turnkey landfill in CHP facility.
	Continued updates to the UNH Greenhouse Gas Emissions Inventory.
Research	Continuation of research on climate variability, air quality, and public and ecological health impacts, including through INHALE and the Ecology, Climate, and Health Working Group.
	Research in biocrops/biofuels and the economics/business models, environmental costs and benefits, and engineering efficiencies of small-scale, local biodiesel production.
Engagement	Continuation of WildCAP program.

RECOMMENDATIONS

While the University of New Hampshire (UNH)'s energy and climate related accomplishments are laudable, the following recommendations if enacted will further increase energy efficiency and lower GHGE and energy costs. These recommendations were generated from the results of this inventory update, from strategies proven effective at other institutions, and from the expertise of UNH's CEI Working Group and ETF members.

Curriculum & Research

- *Expand climate-related curricula*. UNH should continue to expand the number and variety of courses offered that provide students with opportunities to explore climate change impacts and adaptation and mitigation strategies. In addition, existing courses in all departments and disciplines should integrate climate change information and themes where feasible in order to help students understand the relationships among individual and collective choices (from transportation to heating to food purchases), public policies, cultural norms, and climate change.

- Expand climate-related research. UNH should strengthen its research on climate variability, such variability's impacts on ecological and public health, and related adaptation and mitigation strategies. Efforts to build inter-college research programs should be supported in as many ways as possible. Future efforts can use research like UNH's Integrated Human Health and Air Quality Research project (INHALE) as a model. INHALE, which is researching regional climate variability, air quality and public health, involves a wide range of faculty (including from the UNH Institute for the Study of Earth, Oceans, and Space (EOS), the UNH Whittemore School of Business and Economics (WSBE), and UNH School of Health and Human Service (HHS)). What's more, INHALE is engaging a wide range of stakeholders and using the results of this research to create informed public policy and to guide the development of the AIRMAP air quality forecasting research effort.[26] Another excellent research model is UNH's working group on Ecology, Climate, and Health. This working group includes faculty and staff from the Departments of Microbiology, Zoology, Natural Resources, and Public Health, along with researchers from the UNH Office of Sustainability, the UNH Climate Change Research Center, the New Hampshire Veterinary Diagnostic Laboratory, the Jackson Estuarine Laboratory, the New Hampshire Department of Health and Human Services, and the New Hampshire Department of Agriculture. INHALE and the Ecology, Climate, and Health Working Group are examples of emerging work that integrates a range of disciplinary expertise. In order to draw from the broad range of ongoing and potential research in climate change, the ETF should convene a UNH summit entitled "Climate Change and New England: Impacts, Adaptation and Mitigation." Such a summit would help UNH and the growing number and diversity researchers studying climate change related issues in New England to assess and build community interest and integrated research approaches.

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26 To learn more about AIRMAP and INHALE, visit airmap.unh.edu.

On-Campus Stationary Sources

- *Explore the use of biodiesel where appropriate at buildings not connected to the combined heat and power (CHP) facility*. Although the #2 distillate oil currently used to heat outlying farm and greenhouse buildings (which are not connected to the CHP facility) is cleaner burning than #6 oil, another energy alternative for heating these outlying buildings is biodiesel. Biodiesel is a domestic and renewable fuel for use in diesel engines and is derived from natural oils like soybean oil and waste vegetable oil from food operations. Approved by the American Society for Testing and Materials (ASTM), biodiesel is created by a chemical process that removes glycerin from the oil. With minor modifications, biodiesel can be used in any concentration with petroleum-based diesel fuel; typically it is used in concentrations of B-20 (20% biodiesel to 80% petroleum), B-50 (50% of each) and B-100 (100% biodiesel). B-20 does not congeal at low temperatures and can be used with existing equipment, but stronger blends such as B-100 could be used in most equipment with either gasket replacements or other minor modifications. As producing biodiesel requires energy and therefore results in some GHGE, its production should be weighed against the energy saved and emissions prevented through its use. In comparison with more traditional fossil fuels like oil and gasoline, however, biodiesel is cleaner and less polluting. As a result, UNH should explore using biodiesel as one portion of its larger energy plan.

- *Explore alternative electricity-production options*. Even with the CHP facility's output, UNH will still need to purchase 10-20% of its electricity. Every effort should be made to reduce this figure so that on-site electricity production (whether from the CHP facility or from other facilities) meets all UNH electric needs in the most sustainable way possible. UNH should continue to research alternative fuel sources for the CHP facility and for meeting its energy needs not met by the CHP facility. For example, methane from landfilled waste can be recovered and used in place of natural gas or other fossil fuels being used currently at the CHP facility.

- *Explore and invest in "green power" procurement*. According to the U.S. EPA, "green power is a marketing term for electricity that is partially or entirely generated from environmentally preferable renewable energy sources, such as solar, wind, geothermal, biomass, biogas, and low-impact hydro. Green power is sold to support the development of new renewable energy sources."[27] As discussed in the 1990-2003 UNH Greenhouse Gas Inventory, UNH should conduct an analysis of available options for green power procurement and then invest in those that best fit UNH's needs. For example, one option is to purchase green tag "offsets" for any GHGE resulting from the burning of fossil fuels to generate electricity, heat buildings and water, and fuel vehicles owned and operated by the University. Purchasing green tags invests in the development of green power alternatives, and tags can be purchased from a wide variety of organizations, from non-profits to utilities, in amounts that correspond to the MTCDE emitted each year as energy is used.

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27 U.S. EPA Green Power Partnership. (Updated as of October 21, 2005). What is Green Power? www.epa.gov/greenpower/whatis/index.htm.

UNH should then explore participating in the EPA's "Green Power Challenge" to be recognized as a national collegiate leader in green power.[28]

- *Develop purchasing policies and standards that mandate the use of energy efficient products*. Administrators, faculty, and staff should be required to purchase energy efficient equipment and appliances, such as compact fluorescent light bulbs and ENERGY STAR printers, photo copiers, fax machines, and video equipment. Window and interior or stand-alone air conditioners in particular use a great amount of energy; as such, greater investments in more efficient heating, ventilation, and air conditioning (HVAC) systems should be made as appropriate for certain buildings on campus to that building occupants do not feel the need to purchase air conditioners. In addition, all UNH purchasing card (or p-card) holders (those allowed to use a University commercial Mastercard for certain purchases, such as supplies or membership fees, that tend to be under $1,000) should receive as part of their standard p-card training and educational materials information on buying energy efficient items. Finally, all UNH contracts with vendors should mandate that energy efficient items be leased or purchased wherever feasible.

- *Expand university-wide greenhouse gas reduction policies*. UNH should continue to explore all possible policy changes to reduce GHGE. For example, requiring that students, faculty, and staff activate computer power management before logging on to the UNH network (similar to the virus protection requirement currently in place) can lead to large emissions and cost savings. While most computers now come standard with monitor and computer box (CPU's, hard drives, etc.) "sleep modes" to conserve energy, currently students, faculty, and staff are not required to use them. The energy and cost savings of power management, however, is large. For example, if approximately 10,000 computers on campus had activated power management in FY05, UNH would have saved nearly $150,000 in electricity costs and enough kilowatts to light approximately 864 homes for one year. In addition, the CO_2 pollution prevented (approximately 701 MTCDE) would have been equivalent to taking approximately 134 cars off the road.[29]

- *Track and improve energy efficiency in buildings*. Although extensive infrastructure improvements and retrofits have already been completed in many campus buildings, there is still room for additional improvements to increase energy efficiency. For example, equipping all UNH offices with programmable thermostats would allow administrators, faculty, and staff to set day and night temperatures based on use patterns. Temperatures

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28 For more information on the U.S. EPA Green Power Partnership and Green Power Challenge, visit www.epa.gov/grnpower/partners/hi_ed_challenge.htm.

29 This estimate is based on 10,000 computers reducing their annual energy use by about 108 kWh per year and on an average electricity rate of 13.8 cents per kWh. It assumes not all of the estimated 13,165 students and 3,494 full-time equivalent faculty and staff on campus in FY2005 had computers or used power management, and that these 10,000 computers were all Energy Star compliant. In addition, it uses the Lawrence Berkeley National Laboratories (LBNL) 2005 estimation that the average annual energy consumption is 371 kWh for a CPU and 153 for a monitor. Finally, it assumes EPA conversion coefficients of 11,560 lb. CO2 per automobile, 1.43 lb. CO2 per kWh, and 1,250 kWh per year to light the average home. See http://pmdb.cadmusdev.com/powermanagement/quickCalc.html for more information.

could be lowered in winter or raised in summer at night and on weekends when most office areas are empty. As a first step to such efforts, the energy efficiency (i.e., heating and cooling energy and electricity used) of each building on campus should be updated, tracked over time, and compared to other buildings of the same size and type in order to determine how much energy savings are left to be captured. The UNH Energy Task Force (ETF) has already taken the next step by beginning to identify and review what immediate energy efficiency efforts, if funded, would bring high financial and energy reduction returns. In addition, the UNH Energy Office is researching now to track metering data from each campus building and provide this data on a regular basis (such as monthly or even in "real time") online for UNH community use.

- *Strengthen and institutionalize sustainable building design and construction on campus*. Both new construction and renovations to campus buildings should at a minimum adhere to best practices in sustainable building design and construction principles, such as energy and water efficiency and sustainable landscaping. Often initial investments in energy efficient materials and design pay back many-fold over the life of the building while providing educational and research opportunities for those using the building. The ETF is currently reviewing current sustainable building standards to recommend changes to UNH renovation and construction standards. In addition, occupants of James Hall are currently working with UNH Facilities to ensure that the renovated building follows as many sustainable design principles as possible.

Transportation

- *Conduct a new transportation survey of students, faculty, and staff*. A new transportation survey is needed to update the profiles of UNH commuter habits. This 2004-2005 GHGE inventory update relied on transportation survey data from 2001. The increase in transit ridership suggests that habits may have changed since then. Since fuel prices increased in 2005, it is likely that commuter habits may have also changed. Only an updated survey will be able to capture these changes and allow for more accurate emissions estimates. Transportation surveys should be conducted on a regular basis to account for behavioral change and to allow for targeted outreach and education. A new transportation survey is being discussed for 2006.

- *Provide incentives to change commuting behavior*. UNH should continue to expand its policies and practices that provide incentives for faculty, staff, students, and campus visitors to improve their transportation habits through carpooling, use of local and inter-city transit, bicycling, and walking. UNH has put basic systems in place that have demonstrated success in reducing parking demand and increasing transit use. The next generation of practices should look towards expanding that success and providing incentives for positive commuting and travel behaviors. Such strategies should include flexible parking permit systems that generate adequate revenue to fund a balanced transportation system; continued improvements in transit frequency, fleet efficiency, service routes, and facilities; and continued investments in bicycle and pedestrian facility upgrades. In particular, a focus

on improving intra-campus mobility - such as strengthening walking and biking on campus and faculty/staff commuting options - will yield the greatest GHGE reductions.

- *Benchmark current fleet efficiency and mileage and institutionalize vehicle selection standards*. To date, no single UNH policy requires or guides the University community to take account of fuel efficiency or GHGE when making vehicle selection decisions. In addition, no comprehensive benchmarking of fleet efficiency or mileage is in place. UNH should improve its internal data tracking and collection to benchmark fuel efficiency of its licensed motor vehicle fleet. This process will assist departments in assessing efficiency standards and long-term capital replacement of aged fleet. In addition, UNH should institutionalize vehicle selection policies and purchasing procedures that incorporate consideration of right-sizing, fuel efficiency, GHGE and other air pollution standards, and alternative fuels into all vehicle and motor fleet purchasing. These improvements will enable UNH to document and comply with Executive Orders issued by the governor of New Hampshire Governor regarding state agency fleet fuel efficiency standards and with federal Energy Policy Act (EPACT) standards.

- *Track users of the Downeaster station in Durham*. UNH should work with the Amtrak Downeaster Passenger Rail service and C&J Trailways bus service to track who uses these services (i.e., students, faculty, staff, and local community members), how often, for what routes (e.g., to and from Durham, NH, and Boston, MA), and for what reasons. Currently only trips per month to and from each Amtrak Downeaster station are recorded. A more accurate portrait of ridership could help UNH work with Amtrak and C&J Trailways to improve and expand services.

- *Quantify emissions from air travel*. With the very real possibility that the UNH-work related air travel habits of faculty, staff, and students could increase GHGE by 8%, it is imperative to assess the emissions associated with official UNH air travel. Initial efforts could include delegating responsibilities for air travel audits to individual Business Service Center (BSC) officers within departments. Additionally, student programs related to travel abroad, research, and athletics should be assessed through records of actual miles traveled. Once average annual GHGE from air travel are quantified, emissions offsets and reduction strategies can be identified and reviewed.

Waste Management at UNH

- *Itemize and quantify solid wastes*. UNH should survey the composition of the solid waste in its dumpsters and itemize this waste according to location. Such a survey would provide an excellent estimate of the composition of UNH's solid waste and would help to refine GHGE estimates from waste sent to landfill. Combined with an assessment of on-campus recycling habits, student body size, and locations of dumpsters and recycling bins, such a survey also would show how these factors result in certain waste patterns and, as a result, where waste reduction and educational opportunities might lie.

- *Record all landfilled wastes*. As all garbage trucks depositing waste to Turnkey Landfill are weighed, UNH should request to have records kept of its quantities of landfilled waste through its contractual agreement with Waste Management. Doing so will improve the campus's ability to estimate CH_4 emission losses from landfilled waste and to track the progress of waste reduction efforts.

- *Explore methane capture and reuse technologies*. According to estimates of CH_4 emission losses from landfill sites that utilize CH_4 capture and electric generation and to U.S. EPA estimates of CH_4 emission coefficients, the bulk of CH_4 emissions from landfills is released into the atmosphere. Therefore, UNH should explore efficient design measures that capture CH_4 emissions from its landfilled waste and bring these emissions to the CHP facility for heat and electricity generation.

- *Promote and support on-campus recycling more aggressively*. UNH should strengthen its promotion of on-campus recycling. Anecdotal reports from residence hall residents indicate that current recycling systems for disposal and pick up are inadequate (i.e., bins often are overflowing, absent, or infrequently collected). These reports should be addressed and every effort should be made to encourage student, staff, and faculty recycling. One way to motivate recycling is to post signs in all buildings and near as many recycling bins as possible that include regularly updated information on tons of paper, plastic, and metals recycled, the resultant savings in terms of money and resources, and the resultant pollution prevented as those recyclables are turned into new goods. If faculty, staff, and students can see that UNH is still actively recycling, and that this recycling is resulting in real monetary and environmental benefits, then they might be motivated to continue to recycle since they could see that their actions are making a tangible difference.

Engagement & Outreach

- *Promote and support behavior and policy changes*. Through UNH's newly formed ETF and its broader CEI, the university should continue to implement aggressive educational campaigns for students, faculty, and staff aimed at reducing energy use through both behavioral change and larger university policies changes. Behavioral changes include turning off lights, turning thermostats down in winter and up in summer (if air conditioning is available), activating computer power management (including using sleepware and unplugging computers and other appliances when not in use), and washing clothes in cold water. Additional energy use reductions should be promoted through residence hall and on-campus apartment-based contests. As mentioned, examples of policy changes include institutionalization of vehicle selection standards (which should be based on fuel efficiency and emissions standards), sustainable building design and construction principles, and green power procurement.

- *Institutionalize UNH's commitment to sustainability as a core value in all communications and marketing.* At UNH, sustainability is a community way of life: faculty, administrators, staff, and students are working together to integrate the principles and practices of sustainability throughout the "CORE" (curriculum, operations, research, and engagement

efforts) of the university. As such, UNH's commitment to being a Climate Protection Campus - as part of the university's larger sustainability commitment - should be integrated throughout all university marketing, recruitment, orientation, and overall communications efforts. In this way, the entire UNH community and all of its external partners are educated on climate change and UNH's expanding climate protection efforts.

- *Engage with UNH partners and share success stories*. UNH should engage continually with its partners, including faculty and scholars at other institutions of higher education, local, state, and federal agencies, non-profits, and local communities. In particular, UNH should integrate research efforts with these partners where feasible and share success stories on what has and has not worked in terms of reducing GHGE, improving energy efficiency, lowering energy costs, and educating faculty, staff, and students on the relationships among energy choices, climate, and economic and social well-being.

CONCLUSION

UNH has made major strides towards reducing its greenhouse gas emissions and building a Climate Protection Campus by integrating the ethics, science, technology, and policies of greenhouse gas reductions into its community identify and practices. Through the University's construction and initial operation of its new combined heating and power (CHP) facility, the formation of the UNH Energy Task Force, and the completion of a wide range of related curricula, research efforts, and other projects, UNH has developed a unified Climate Education Initiative (CEI) that links the entire UNH community and that has generated many results, including:

- Reducing emissions of carbon dioxide and other greenhouse gases, as well emissions of criteria pollutants like sulfur dioxide and nitrous oxide.
- Researching, developing, and demonstrating innovative solutions to energy challenges.
- Researching climate variability, air quality prediction, and public health issues related to climate change.
- Educating students in all fields about the relationship among human activities, climate, health, and civic and professional actions.
- Continuing to develop the entire University community as a sustainability model for the state and region through integrated policies that link energy, transportation, building design and construction, land use, and sustainable agriculture.

The University community and its partners should continue to build on these efforts in order to further reduce energy use and resulting greenhouse gas emissions and to enhance UNH's leadership as a regional model of sustainability and as a Climate Protection Campus.

In addition, under the umbrella of the CEI, the UNH ETF should lead University efforts to educate faculty, staff, and particularly students about the relationships among energy choices, climate, and economic and social well-being. While faculty and staff can apply the sustainability lessons they learn while at UNH both on campus and at home, students can carry these lessons into their personal and professional lives long after graduation.

After all, UNH's commitment to sustainability extends far beyond its New Hampshire home. And as the impacts of climate change in New England continue to increase, the entire UNH community *must* strengthen and expand its commitment to climate protection in its curriculum, operations, research, and engagement.

APPENDIX I: INVENTORY METHODOLOGY CONSIDERATIONS

The 1990-2003 UNH Greenhouse Gas Emissions (GHGE) Inventory used the University of New Hampshire's (UNH) Office of Sustainability's Microsoft Excel-based Emissions-Calculator Version 3.0. In contrast, an updated version of the calculator (v4.1) was used to calculate emissions from 1990-2005 for this 2004-2005 GHGE Inventory Update. The revised calculator includes changes to its methodology that impact GHGE estimates. Although the general protocol for estimating emissions is still determined by the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Environmental Protection Agency (EPA), some features of the older calculator were discontinued or altered to allow the user to access data more easily and to compare results with other institutions on a regional basis. Specifically, the electric fuel mix data are now based on the eGRID data system, which contains data from all electric grid systems across the US. Additionally, various advances in the scientific understanding of the reactivity of greenhouse gases and each gas's 100-year global warming potential (GWP) have led to minor differences in calculations of the historical emissions profile at UNH. On average, these changes resulted in less than a 3% difference from previously reported values. Since the IPCC recommends addressing changes in calculation methodologies that result in a greater than 10% difference, we did not further investigate the effects of switching to new software for emissions.

Other methodological changes worth noting follow.

Upstream Emissions

In previous years, the UNH emissions inventory included "upstream emissions" - the emissions associated with the collection of source fuel (such as crude oil) and the transport, storage, and refining of these fuels as they are brought to the location of combustion (such as the university boiler or an automobile). For example, it takes fuel to power an oil barge across the ocean or to drive a tanker truck to deliver gasoline. These emissions are estimated in the U.S. Department of Energy's 1999 report *The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation*.[30] However, to meet the guidelines of the IPCC and EPA, the new v4.0 calculator does not consider upstream emissions but instead deems them the responsibility of the industries providing such transport, storage, and refining processes. This revision to IPCC and EPA guidelines was the result of ongoing efforts to streamline emissions accountability by sector. Calculations of upstream emissions were not included in the UNH FY04 and FY05 audit; instead, only UNH direct emissions are reported. It is worth noting that in previous years UNH upstream emissions generally increased total GHGE by 15%.

30 Wang, Michael. (August 1999). The Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) Model Version 1.5. Center for Transportation Research, Argonne National Laboratory, U.S. Department of Energy, www.transportation.anl.gov/pdfs/TA/264.pdf.

GWP Values

IPCC assessment reports constantly improve upon the body of climate change knowledge by including the latest advances in technology and methodological considerations in order to provide the most accurate information available. For instance, in the third assessment report by the IPCC, the 100-year GWP of methane changed from 21 to 23, while the GWP of nitrous oxide changed from 310 to 296. Changes like these have been incorporated into v4.0 of the calculator along with several other changes to chemical refrigerants and other chemicals with known GWP values. These kind of changes in calculations had only a minor effect on UNH historical emission data.

Purchased Electricity Emissions

The v3.0 calculator relied on specific fuel mix data from the Independent System Operators New England Power Pool (ISO NEPool) to measure the emissions resulting specifically from UNH electricity demand. These emissions were calculated based on the exact fuel mix (i.e., percentage of coal, nuclear, hydropower, etc.) consumed by electric utilities to generate power. These exact percentages have become progressively more difficult to obtain in recent years. To eliminate the potential of an incomplete inventory that would result from inaccessibility to these data, new methods for estimating GHGE from electricity production were developed. The v4.0 calculator relies on the EPA's e-GRID tool to access fuel mix data.[31] eGRID is the EPA's comprehensive source of data on the environmental characteristics of all electric power generated in the United States. Integrating 23 different federal data sources, eGRID provides information on air pollutant emissions and fuel mixes for individual power plants, generating companies, states, and regions of the power grid.[32] Incorporating eGRID into the v4.0 calculator's emissions methodology facilitated the collection of fuel consumption mix data and provided more generalized fuel mix data for calculations. Replacing v3.0 electric emissions methodology with eGRID also had the largest effect on the historical GHGE of UNH. However, eGRID effectively provides a level playing field for comparing UNH emissions estimates to those of other regional institutions that may have otherwise specified a different source fuel mix.

Transportation

University Fleet

In the 1990-2003 UNH Greenhouse Gas Emissions (GHGE) Inventory, UNH fleet transportation was estimated by UNH Transportations Services to account for 70% of total fleet fuel consumption. Since the last inventory, record keeping at UNH has improved. Data from the New Hampshire Department of Transportation fueling station on campus now show

31 www.epa.gov/cleanenergy/egrid/index.htm

32 www.epa.gov/cleanenergy/epaclean.htm

that, contrary to earlier estimates, UNH transit fleet only accounts for approximately 44% of all liquid fuel consumed by university vehicles.

Since UNH Transportation Services has streamlined much of its transit operations between 1990 and 2005, it is likely that transit fuel consumption has been more during the years in question and therefore may more closely resemble a 50% share of UNH fleet fuel consumption.[33] We applied this percent fuel mix to historical UNH transit fleet records to calculate actual UNH fleet fuel consumption where data were not available.

Commuters

Historical calculations of GHGE from energy consumed by commuter transportation to and from UNH changed slightly in the updated inventory due to new average fuel efficiency data for vehicles from the National Transportation Bureau (NTB). The average fuel efficiency value in the v3.0 calculator (approximately 25 miles per gallon (mpg)) did not include the use of motorcycles, light trucks, and sport utility vehicles in its account of vehicles used for commuter transportation purposes. Instead, v3.0 only considered average fuel efficiency for passenger vehicles. Data from the NTB show that these other classes of vehicles make up an average of 35% of vehicles on the road throughout the nation. Therefore, new annual fuel efficiency weighted averages were calculated and incorporated into the v4.0 calculator in order to reflect more accurately the national demand for vehicles other than passenger cars. This change resulted in a minor net increase in GHGE.

In addition, the previous calculator's methodology for estimating student, faculty, and staff commuting did not include data on commuters, carpoolers, and their respective habits from the 2001 UNH transportation survey. Specifically, the v3.0 calculator did not account for carpooling commuter habits in its methodology, subsequently underestimating commuter habits within the UNH community during the average five-day work week. This omission has since been corrected in the v4.0 calculator by including more comprehensive estimates from data compiled from the 2001 UNH transportation survey.

33 UNH Greenhouse Gas Emission Inventory Report, 1990-2003.

APPENDIX II: SUMMARY DATA AND CALCULATIONS

	Purchased Electricity	On-campus Stationary	Transportation				Agriculture	Solid Waste	Refrigerants & Chemicals	Total Emissions	Offsets				Net Emissions
Fiscal Year			Faculty/Staff Commuters	Student Commuters	UNH Fleet	Total					Composting	Forest Preservation	Recycling	Total	
1990	17,761	25,434	5,482	2,582	2,531	10,595	890	0	0	54,681	0	-96	0	-96	54,681
1991	17,620	23,405	5,234	2,444	2,531	10,209	913	0	0	52,147	0	-96	0	-96	52,147
1992	17,833	27,592	5,473	2,657	2,532	10,662	910	0	0	56,997	0	-96	0	-96	56,997
1993	18,073	25,947	5,645	2,893	2,533	11,070	900	0	0	55,990	0	-96	0	-96	55,990
1994	17,935	27,591	5,640	2,917	2,527	11,084	905	0	0	57,515	0	-96	0	-96	57,515
1995	18,453	24,821	5,492	2,923	2,475	10,890	919	0	0	55,084	0	-96	0	-96	55,084
1996	20,938	34,652	5,407	2,871	2,452	10,730	897	0	0	67,217	0	-96	0	-96	67,217
1997	20,847	31,645	5,314	2,868	2,315	10,496	915	901	0	64,804	0	-96	0	-96	64,804
1998	20,039	29,373	5,476	2,737	2,445	10,659	888	870	0	61,829	0	-96	0	-96	61,829
1999	20,431	29,906	5,573	2,583	2,350	10,506	904	988	0	62,734	0	-96	0	-96	62,734
2000	20,678	27,482	5,727	2,609	2,321	10,657	906	846	0	60,568	0	-96	0	-96	60,568
2001	21,960	30,399	5,869	2,616	2,292	10,777	966	881	14	64,997	0	-96	0	-96	64,997
2002	23,303	27,362	6,093	2,659	2,262	11,014	950	903	22	63,554	0	-96	0	-96	63,554
2003	23,703	35,077	5,940	2,732	2,232	10,904	955	903	0	71,542	0	-96	-1,757	-1,853	69,785
2004	25,008	34,115	6,248	2,659	2,147	11,054	962	903	0	72,042	0	-96	0	-96	72,042
2005	23,811	32,562	7,041	2,665	2,022	11,728	956	903	224	70,185	-28	-96	-1,736	-1,861	68,324

Table A1. UNH Direct Greenhouse Gas Emissions 1990-2005 (Metric Tons Carbon Dioxide Equivalents)

	Electricity	On Campus Stationary Sources					University Fleet			Commuters	
Fiscal Year		Residual Oil (#5 - #6)	Distillate Oil (#1 - #4)	Natural Gas	Propane	Incinerated Waste	Gasoline Fleet	Diesel Fleet	Natural Gas Fleet	Faculty / Staff Gasoline	Students Gasoline
1990	279,162	231,658	30,931	-	6,529	831,888	21,577	13,317	-	75,901	35,754
1991	276,947	197,196	37,812	-	8,531	840,807	21,577	13,317	-	72,481	33,845
1992	280,286	241,958	53,667	-	9,558	737,577	21,577	13,317	-	75,757	36,775
1993	284,067	199,212	50,857	-	25,092	905,499	21,577	13,317	-	78,094	40,019
1994	281,888	227,532	51,735	-	28,731	741,717	21,483	13,317	-	77,939	40,314
1995	290,045	198,841	44,999	-	31,401	706,095	19,626	14,505	-	76,169	40,533
1996	329,104	333,302	56,111	-	45,371	250,965	20,290	13,556	-	75,064	39,854
1997	327,670	204,883	49,089	196,311	23,634	-	19,123	12,837	-	73,804	39,831
1998	314,968	179,651	32,423	234,059	7,283	-	17,709	16,032	-	76,142	38,058
1999	321,125	297,612	24,079	80,327	7,271	-	17,254	15,178	-	77,490	35,913
2000	325,008	282,315	18,228	66,349	6,465	-	16,462	15,555	-	79,584	36,265
2001	345,162	277,043	22,289	122,136	7,709	-	15,671	15,930	-	81,570	36,362
2002	366,269	251,181	22,884	102,716	7,453	-	14,876	16,307	-	84,682	36,949
2003	372,554	337,574	26,060	113,597	9,119	-	14,084	16,683	-	82,551	37,965
2004	393,065	352,222	24,664	75,658	9,057	-	15,008	14,524	117	86,825	36,956
2005	374,256	327,650	24,761	82,604	9,145	-	13,448	13,014	1,944	97,845	37,037

Table A2. UNH Energy Use Summary (in millions of British thermal units or MMBtu) for Major Sources of Emissions from 1990-2005.

		Energy Consumption	CO_2	CH_4	N_2O	eCO_2	eCO_2
		MMBtu	kg	kg	kg	Short Tons	Metric Tonnes
Purchased Electricity		374,256	23,690,883	453	371	26,247	**23,811**
Stationary Sources		444,161	32,280,382	5,268	542	35,893	**32,562**
Transport Total		163,288	11,458,453	2,161	741	12,927	**11,728**
	UNH Fleet	28,406	1,989,176	269	90	2,229	**2,022**
	Student Commuters	37,037	2,600,142	519	179	2,938	**2,665**
	Faculty/Staff Commuters	97,845	6,869,136	1,372	472	7,761	**7,041**
	Air Travel	-	-	-	-	-	**-**
Agriculture Total		-	-	38,481	241	1,054	**956**
Solid Waste		-	-	39,281	-	996	**903**
Refrigeration						247	**224**
Total		**981,704**	**67,429,718**	**85,644**	**1,895**	**77,364**	**70,185**
Offsets						**(2,051)**	**(1,861)**
	'Green' Electric Credits					**-**	-
	Composting					**(31)**	(28)
	Forest Preservation					**(106)**	(96)
	Recycling					**(1,914)**	(1,736)
Net Emissions						**75,313**	**68,324**

Table A3. UNH Fiscal Year 2005 Energy Consumption and Greenhouse Gas Emissions by Mass and Metric Tons Carbon Dioxide Equivalents (eCO_2).

Fiscal Year	Electricity Used (kWh)	* eGRID Coefficient	* 100 y Global Warming Potential	SUM ($kg\ eCO_2$)	1000 kg eCO_2 / metric ton eCO_2 (MTCDE)
1990	43,344,000			17,761,064	17,761
1991	43,000,000	(converts kWh	(converts kg GHG	17,620,103	17,620
1992	43,518,428	to kg GHG)	to kg eCO2)	17,832,540	17,833
1993	44,105,455			18,073,086	18,073
1994	43,767,261	* kg CO_2 / kWh	* 1 kg eCO_2 / kg	17,934,504	17,935
1995	45,033,744	0.40770	CO_2	18,453,470	18,453
1996	51,098,096			20,938,459	20,938
1997	50,875,573	* kg CH_4/ kWh	*23 kg eCO2 / kg	20,847,276	20,847
1998	48,903,360	0.0000077916	CH_4	20,039,122	20,039
1999	49,859,266			20,430,824	20,431
2000	50,462,168	* kg N_2O/ kWh	* 296 kg eCO2 / kg	20,677,875	20,678
2001	53,591,328	0.0000063873	N_2O	21,960,110	21,960
2002	56,868,538			23,303,012	23,303
2003	57,844,401			23,702,891	23,703
2004	61,028,985			25,007,838	25,008
2005	58,108,616			23,811,159	23,811

Table A4. Calculations for Greenhouse Gas Emissions resulting from Electricity Use at UNH 1990-2005.

* eGRID coefficient values for the masses of greenhouse gases produced in electrical generation were supplied by the U.S. EPA and represent the Northeast Power Coordinating Council New England Region long-term average fuel mix ratios. 100-year Global Warming Potential values were provided by IPCC third assessment report.

Fiscal Year	UNH Students	Vehicle Fuel Efficiency (mpg)	% Students Commuting	% Students Riding Alone	% Students Carpooling	Trips / Day	Days / Year	Miles / Trip	Total Distance (miles)	Fuel Consumption (gallons)
1990	11566	19.9	34%	93%	2%	0.64	154	12	4,355,863	219,273
1991	11468	20.6	33%	93%	2%	0.64	154	12	4,246,911	206,328
1992	11874	20.5	36%	93%	2%	0.64	154	12	4,698,284	229,428
1993	12257	20.1	38%	93%	2%	0.64	154	12	5,124,087	254,307
1994	12397	20.2	38%	93%	2%	0.64	154	12	5,211,916	258,206
1995	12518	20.4	38%	93%	2%	0.64	154	12	5,346,438	261,685
1996	12414	20.4	38%	93%	2%	0.64	154	12	5,230,816	256,129
1997	12454	20.6	38%	93%	2%	0.64	154	12	5,275,286	256,566
1998	12209	20.6	37%	93%	2%	0.64	154	12	5,002,906	242,541
1999	11795	20.4	35%	93%	2%	0.64	154	12	4,587,492	224,664
2000	12059	20.8	36%	93%	2%	0.64	154	12	4,768,810	228,856
2001	12120	21.1	36%	93%	2%	0.64	154	12	4,850,817	230,313
2002	12262	20.9	36%	93%	2%	0.64	154	12	4,907,650	234,707
2003	12905	21.2	36%	93%	2%	0.64	154	12	5,165,000	243,786
2004	13129	22.1	36%	93%	2%	0.64	154	12	5,254,652	237,767
2005	13165	22.1	36%	93%	2%	0.64	154	12	5,269,060	238,419

Table A5. Calculations for UNH Student Commuting Miles and Fuel Consumption 1990-2005.

Vehicle Fuel Efficiency (mpg) was calculated using data from the U.S. Department of Transportation, the Bureau of Transportation Statistics, and the National Transportation Statistics Report BTS05-08 and reflects the weighted efficiency of passenger vehicles, other four wheel, two axle light duty vehicles, and motorcycles registered and on the road for each fiscal year. Percent Students Commuting reflects actual data from UNH Transportation Department 1990-1999 records with the applied average for 2000-2005. Percent Students Riding Alone, Percent Students Carpooling, and Trips per Day were calculated from data reported in the 2001 UNH Transportation Survey (UNH Survey Center). Days per Year was calculated from the number of days of classes and exams counted from the 2000-2001 UNH academic calendar. Miles per Trip was calculated from the average roundtrip distance from Newmarket and Dover, the two most popular towns besides Durham in which students live, to Durham. Total Distance was calculated as: [(UNH Students * % Students Commuting * %Students Riding Alone) + (UNH Students * % Students Commuting * % Carpooling) / 2] * Trips/Day * Days/Year * Miles/Trip. Fuel Consumption was calculated by dividing Total Distance by Vehicle Fuel Efficiency.

Fiscal Year	Instructional Faculty	Vehicle Fuel Efficiency (mpg)	% Faculty Commuting	% Faculty Riding Alone	% Faculty Carpooling	Trips / Day	Days / Year	Miles / Trip	Total Distance (miles)	Fuel Consumption (gallons)
1990	708	19.9	93%	85%	4%	0.96	154	27	2,296,133	115,587
1991	713	20.6	93%	85%	4%	0.96	154	27	2,312,348	112,341
1992	729	20.5	93%	85%	4%	0.96	154	27	2,364,238	115,451
1993	736	20.1	93%	85%	4%	0.96	154	27	2,386,940	118,463
1994	724	20.2	93%	85%	4%	0.96	154	27	2,348,023	116,324
1995	730	20.4	93%	85%	4%	0.96	154	27	2,367,481	115,878
1996	737	20.4	93%	85%	4%	0.96	154	27	2,390,183	117,036
1997	743	20.6	93%	85%	4%	0.96	154	27	2,409,642	117,194
1998	738	20.6	93%	85%	4%	0.96	154	27	2,393,426	116,034
1999	729	20.4	93%	85%	4%	0.96	154	27	2,364,238	115,784
2000	737	20.8	93%	85%	4%	0.96	154	27	2,390,183	114,705
2001	760	21.1	93%	85%	4%	0.96	154	27	2,464,775	117,026
2002	792	20.9	93%	85%	4%	0.96	154	27	2,568,555	122,840
2003	783	21.2	93%	85%	4%	0.96	154	27	2,539,367	119,857
2004	824	22.1	93%	85%	4%	0.96	154	27	2,672,335	120,920
2005	834	22.1	93%	85%	4%	0.96	154	27	2,704,766	122,388

Table A6. Calculations for UNH Instructional Faculty Commuting Miles and Fuel Consumption 1990-2005.

Vehicle Fuel Efficiency (mpg) was calculated using data from the U.S. Department of Transportation, the Bureau of Transportation Statistics, and the National Transportation Statistics Report BTS05-08 and reflects the weighted efficiency of passenger vehicles, other four wheel, two axle light duty vehicles, and motorcycles registered and on the road for each fiscal year. Percent Faculty Commuting, Percent Faculty Riding Alone, Percent Faculty Carpooling, and Trips per Day were calculated from data reported in the 2001 UNH Transportation Survey (UNH Survey Center). Days per Year was calculated from the number of days of classes and exams counted from the 2000-2001 UNH academic calendar. Miles per Trip was calculated from faculty address data (UNH Human Resources). Total Distance was calculated as: [(Instructional Faculty * % Faculty Commuting * %Faculty Riding Alone + (Instructional Faculty * % Faculty Commuting * % Faculty Carpooling) / 2)] * Trips/Day * Days/Year * Miles/Trip. Fuel Consumption was calculated by dividing Total Distance by Vehicle Fuel Efficiency.

APPENDIX III: LIST OF ACRONYMS

ACRONYM	FULL NAME
AFV	alternative fuel vehicle
ASTM	American Society for Testing and Materials
B-100	100% biodiesel
B-20	20% biodiesel, 80% low emission diesel
B-50	50% biodiesel, 50% low emission diesel
BSC	Business Service Center
BTS	Bureau of Transportation Statistics
BTU	British Thermal Unit (for measuring energy)
C	carbon
CA-CP	Clean Air - Cool Planet
CARB	California Air Resources Board
CDE	Carbon Dioxide Equivalents
CEI	Climate Education Initiative
CH_4	methane
ChE	Chemical Engineering
CHP	combined heat and power (or cogeneration) facility
CNG	compressed natural gas

ACRONYM	FULL NAME
CO_2	carbon dioxide
CPU	central processing unit
CRT	cathode ray tube
E85	85% ethanol, 15% low emission diesel
eCO_2	equivalents of carbon dioxide
ENE	Environmental Engineering
EOS	UNH Institute for the Study of Earth, Oceans, and Space
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act
ESAD	equivalent still air distance
ESCI	Earth Sciences
ETF	UNH Energy Task Force
F	degree(s) Fahrenheit
ft^2	square foot
FY	Fiscal Year
GHG	greenhouse gas
GHGE	greenhouse gas emissions
GSF	gross square footage
GWP	Global Warming Potential
HCFC-22	chlorodifluoromethane
HFC	hydrofluorocarbons
HHS	UNH School of Health and Human Service
HVAC	heating, ventilation, and air conditioning

ACRONYM	FULL NAME
INHALE	Integrated Human Health and Air Quality Research
IPCC	Intergovernmental Panel on Climate Change
ISO NEPool	Independent System Operators New England Power Pool
kg	kilogram
kWh	kilowatt-hour
LCD	liquid crystal display
MMBTU	1,000,000 British Thermal Units
MPH	Masters of Public Health
MSW	municipal solid waste
MTCDE	Metric Tons Carbon Dioxide Equivalents
MWh	megawatt-hour
N_2O	nitrous oxide
NEG/ECP	New England Governors/Eastern Canadian Premiers
NEPool	New England pool of energy providers
NHDOT	New Hampshire Department of Transportation
NOx	nitrous oxides
NR	Natural Resources
NTB	National Transportation Bureau
ORNL	U.S. Department of Energy's Oak Ridge National Laboratory
OS	UNH Office of Sustainability
p-card	purchase card/UNH credit card for authorized employees
PFC	perfluorocarbons
PHP	Public Health
$PM_{2.5}$	small particulate matter
POLT	Political Science

ACRONYM	FULL NAME
RGGI	Regional Greenhouse Gas Initiative
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
SOx	sulfur oxides
UNH	University of New Hampshire
UNHM	University of New Hampshire Manchester
WSBE	UNH Whittemore School of Business and Economics

Produced through the collaborative efforts of the UNH Office of Sustainability, the UNH Climate Education Initiative, and Clean Air - Cool Planet, this 2004 - 2005 update to UNH's 1990 - 2003 Greenhouse Gas Emissions Inventory serves as a tool for measuring the University's impact on regional and global climate change. The 2004-2005 Greenhouse Gas Emissions Inventory Update summarizes UNH's greenhouse gas emissions from all major sources, including the production of energy, transportation, and agriculture, among others.

Since 1991, UNH's greenhouse gas emissions (GHGE) have continued to increase with increases in the University's population and improvements in infrastructure. Despite a reduction in emissions between 2003 and 2005, there has been a net increase of 25% in GHGE from 1990 to 2005. UNH is poised to deal with the challenge of reducing its GHGE, however. Overseen by the UNH Office of Sustainability (OS), the UNH Climate Education Initiative (CEI) is actively engaging the University community in climate change education and greenhouse gas emissions reduction efforts across campus and beyond. Emissions reductions and subsequent improvements in air quality are complemented by related integrative research, interdisciplinary curricula at the undergraduate and graduate levels, and broad-based outreach programs that educate students, faculty, administrators, staff, and the larger community about the relationships among energy choices, climate, and economic and social well-being. Demonstrating the University's institutional commitment to the mission and goals of the CEI, in the fall of 2005 a university-wide Energy Task Force was formed to develop immediate and future actions that lower energy costs, improve energy conservation, reduce greenhouse gas emissions, and increase awareness of and engagement in behaviors around energy use and climate change. What's more, as prior GHGE inventories demonstrate, UNH can achieve significant emissions reductions with substantial cost savings and educational benefits. Examples include the construction of a new combined heating and power (CHP) facility, which will reduce UNH's GHGE by approximately 40% once online in mid-2006, and infrastructure improvements, including lighting retrofits and installation of low-flow water fixtures.

As a Climate Protection Campus and regional leader in addressing climate change and conserving energy, UNH is committed to being a model sustainable community in the state and region that continually reduces its greenhouse gas emissions. This 2004-2005 Greenhouse Gas Emissions Inventory Update outlines recommendations that the University can follow to continue to expand this leadership role.

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