Carbon Neutrality at Middlebury College:

A Compilation of Potential Objectives and Strategies to Minimize Campus Climate Impact

DRAFT PREPARED FOR THE CARBON REDUCTION INITIATIVE AT MIDDLEBURY COLLEGE

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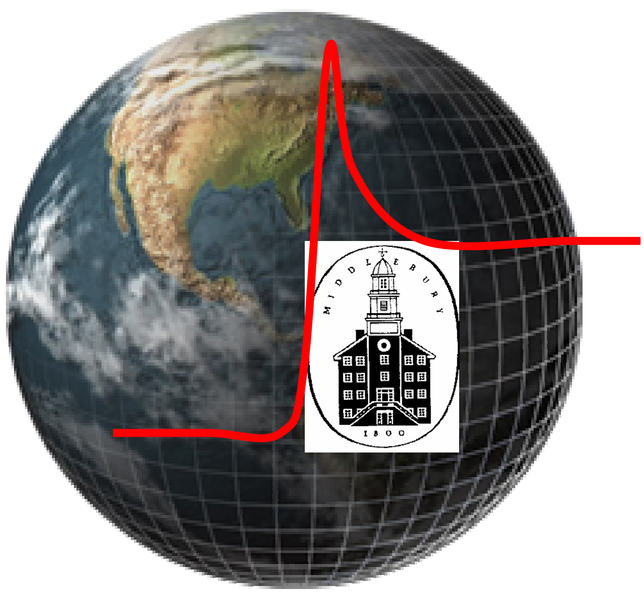

Contribution of the Students and Faculty of ES 010 “The Scientific and Institutional Challenges of Becoming Carbon Neutral” to the Carbon Reduction Initiative Working Group of the Community Council

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Table of Contents

Foreword

The first meeting of the students and faculty of ES 010 “The Scientific and Institutional Challenges of Becoming Carbon Neutral” was held on January 6, 2003. The format of the course was developed in conjunction with ongoing efforts of the Carbon Neutral Subcommittee of the Environmental Council and the purposes of the newly-established Carbon Reduction Initiative Working Group of the Community Council of Middlebury College. The goal presented to ES 010 students was to assess available and emerging technologies and economic instruments that, if implemented, would create reductions in campus Carbon Dioxide Equivalent (CDE) emissions (relative to the most recent complete emissions inventory by Doug Dagan ’03) or would enhance the rate of CDE sequestration, thereby offsetting some fraction of the emissions.

The criteria used for assessment include the following: speed of implementation, estimated lifetime of the technology/instrument, magnitude of the potential CDE reduction, start-up and operating costs, cost per metric tonne CDE, and additional environmental, social, or public relations costs and benefits of implementation. With these criteria in mind, students were divided into five (5) sectors within the campus carbon footprint to better examine the specifics of these criteria in the context of this campus. These sectors now comprise the central five chapters of this document and are titled: Space Heating and Cooling, Electricity, Transportation, Solid Waste, and Sequestration. Within each category students were encouraged to look for both emissions reductions and offsets to campus emissions.

This volume, representing the work of sixteen students and two faculty over the course of four weeks of classes during Winter Term 2003, presents those strategies deemed most likely to a) be feasible within the constraints of Middlebury College operations, b) produce the greatest net reduction in campus CDE emissions, or c) have the greatest long-term potential for significant mitigation of campus climate impact. Indeed, various combinations of the strategies outlined in this document could bring this campus to a net CDE emission of zero – defined herein as carbon neutrality.

The strategies assessed here are not intended to be an exhaustive evaluation of all possibilities, as such an evaluation would extend far beyond the time allotted to the course. In addition, much of the information gathered in this effort is time-sensitive and will require periodic revision to preserve the accuracy of the assessment. Rather, we hope that this document will prove to be a necessary, thoughtful, and useful first step in the College’s assessment of carbon reduction.

As is necessarily the case with a document of this complexity, the success of this report has depended first and foremost on the knowledge, enthusiasm, and cooperation of numerous experts, both on campus and elsewhere, who served in many different capacities. We would like to express our gratitude to all those who have contributed to this document from the Middlebury College Environmental Affairs, Facilities Management, Facilities Planning, (others?) and Budget Offices, as well as to the participants of the College Climate Response and Northeast Campuses for Climate Action meetings who have provided valuable information and insight to this project. We would especially like to thank Mike Moser from the Facilities Management staff, without whose time, commitment, and enthusiasm this report would not have been possible.

Table of Definitions, Acronyms, Abbreviations, and Chemical Formulae

Carbon neutrality	Having a net CDE emission of zero, achieved by reducing sources, increasing sinks, or offsetting emissions by reducing emissions outside the footprint.
CDE	Carbon dioxide equivalents; includes carbon dioxide, methane, nitrous oxide, and in very few cases, other greenhouse gases like fluorocarbons and sulfur hexafluoride. The CDE for gases other than carbon dioxide is calculated by multiplying the mass of a gas by its global warming potential, as defined by the IPCC.
CH_4	Methane, generated by the College through the landfilling of its solid waste; a greenhouse gas with GWP = 21.
CO_2	Carbon dioxide; the primary anthropogenic greenhouse gas with GWP = 1.
Cogeneration	A process in which a boiler is used to produce simultaneously both steam for space heating and cooling and electricity. This type of process maximizes the efficiency of energy capture from a boiler while minimizing the “waste” energy.
GHG	Greenhouse Gas; those gases whose chemical properties allow significant absorption of radiation at infrared wavelengths.
GWP	Global Warming Potential; a multiplier determined through empirical and theoretical scientific studies based on the combination of the infrared absorption coefficient of a gas and its atmospheric lifetime, normalized to that of carbon dioxide. The GWP is calculated on a per mass basis, and therefore has units of, e.g., kg GHG/ kg CO_2 or tonne GHG/ tonne CO_2.
LFGTE	“Landfill Gas to Energy”; heating and electricity production via combustion following methane capture from a landfill site.
MTCDE	Metric tonnes of carbon dioxide equivalent emissions. 1 metric tonne = 1.1023 imperial tons.
N_2O	Nitrous oxide; a greenhouse gas with GWP = 310.
Offset	A reduction of MTCDE that is achieved through purchases in a market.
Sequestration	The capture and storage of carbon that would otherwise be emitted and remain in the atmosphere.

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I. Introduction to Climate Change and Carbon Neutrality

I.1 The Global Climate View

I.1.1 The State of the Science

In the years between the publication of the Second (1995) and Third (2001) Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC), the scientific understanding of climate change has continued to improve. Based on the most recent report by Working Group I: The Scientific Basis[1] of the IPCC, confidence in the ability of models to project future climate has increased, a growing collection of observations indicates that the globe is warming and the climate is changing, and there is increasing evidence that most of the warming observed over the last 50 years is attributable to human activities.

What drives changes in climate?

The Earth's climate is determined by an energy balance between incoming radiation, primarily visible and UV radiation from the Sun, and outgoing radiation, infrared radiation emitted by the Earth itself as a function of its temperature. This balance is determined by a number of factors; the dominant factors are the distance of Earth from the Sun and the mass of the planet that determines the thickness of the atmosphere. Based on these two factors alone, the Earth would have a global temperature of -20 ^{o}C (4 ^{o}F), well below the freezing point of water. It is a third factor, the composition of the Earth's atmosphere, that has a moderating influence on global temperature, changing it in smaller ways that nevertheless have a dramatic impact on living systems.

The effect of atmospheric composition can be broken down into two primary components, greenhouse gases and aerosols. Greenhouse gases are those having chemical properties that cause them to absorb infrared radiation as it is emitted from the Earth's surface, thereby changing the energy balance between incoming and outgoing radiation. The cumulative effect of absorption by greenhouse gases dispersed in the lower atmosphere is to raise the equilibrium temperature of the Earth's surface (positive radiative forcing). Aerosols are microscopic solid or liquid particles at sizes small enough that they remain suspended in the atmosphere for long periods of time. Aerosols have many compositions and in many cases have competing impacts on climate. For example, many aerosols reflect incoming radiation, thereby preventing it from being absorbed at the Earth's surface. This reflection tends to reduce the equilibrium temperature of the Earth's surface (negative radiative forcing). However, aerosols may also absorb outgoing radiation, leading to a positive radiative forcing. In the case of both greenhouse gases and aerosols, the interaction of these effects is complex. The amount of radiative forcing depends on the atmospheric concentration of greenhouse gases and aerosols and the specific chemical properties of those substances.

Many greenhouse gases and aerosols are naturally-occurring: water vapor, carbon dioxide, ozone, methane, nitrous oxide, sulfate aerosols from volcanic eruptions, sea salt aerosols from wave-breaking at the ocean surface, and mineral dust from weathering. Concerns about climate change arise from the enhanced greenhouse effect created by anthropogenic (human-caused) emissions of large quantities of long-lived greenhouse gases, as well as aerosols. The IPCC has identified emissions of the following gases as being of primary concern: carbon dioxide, methane, nitrous oxide, CFCs and other fluorocarbons, and sulfur hexafluoride. Of these, the most significant effect is currently due to carbon dioxide, due to the sheer magnitude of the emission associated with fossil fuel combustion and land-use change (e.g. deforestation).

What do we know about human-caused climate change?

Working Group I of the IPCC rates the following conclusions to be either *very likely* (90-99% confidence) or *virtually certain* (> 99% confidence)[1]:

- The global average surface temperature has increased over the 20th century by 0.6 +/- 0.2 ^oC (1.08 +/- 0.36 ^oF).
- The 1990s was the warmest decade in the instrumental record (since 1861).
- Snow cover has decreased about 10% and the duration of lake and river ice cover has decreased by about two weeks in the Northern Hemisphere over the 20th century.
- Mountain glaciers in non-polar regions have undergone widespread retreat.
- The global average sea level has increased between 0.1 and 0.2 meters (4 to 8 inches).
- The frequency of heavy precipitation events has increased by 2 - 4 % in the mid- and high-latitudes of the Northern Hemisphere over the last half of the 20th century.
- Warm episodes of the El Nino-Southern Oscillation phenomenon have been more frequent, persistent, and intense since the mid-1970s.
- The present atmospheric concentration of carbon dioxide (CO_2) has not been exceeded during the past 420,000 years (in the past 20 million years, 66-90% confidence).
- The present atmospheric concentration of methane (CH_4) has not been exceeded during the previous 420,000 years.
- The present atmospheric concentration of nitrous oxide (N_2O) has not been exceeded in the previous thousand years.
- Emissions of CO_2 from fossil fuel combustion will be the dominant influence on changes in the atmospheric CO_2 concentration in the 21st century.

- As atmospheric CO_2 increases, ocean and land will take up a decreasing fraction of anthropogenic emissions.
- Carbon cycle models predict that atmospheric CO_2 concentrations will fall in the range of 490 to 1260 parts per million (ppm) by 2100. Current concentrations are ~ 370 ppm, and pre-industrial concentrations were ~ 280 ppm.
- To stabilize the radiative forcing of CO_2, reductions in emissions are necessary. For stabilization at a CO_2 concentration of 450 ppm, global anthropogenic CO_2 emissions must drop below 1990 levels within a few decades and continue to decrease steadily to a very small fraction of current emissions thereafter.

I.1.2 The Political and Economic Landscape

The global community began to focus on climate change in 1992 at the Rio Earth Summit, where the United Nations Framework Convention on Climate Change (UNFCC) -- a set of guidelines for the voluntary reduction of GHGs -- was adopted by most countries of the world. Since it soon became evident that voluntary measures were ineffective, a series of international negotiations which began in 1995 lead to the creation of the Kyoto Protocol in 1997, a set of mandatory reductions of GHG emissions which as of 22 January 2003, has been ratified by 104 countries**.**

Despite the fact that the United States accounts for about 25 percent of the current share of anthropogenic GHGs, neither the Clinton nor Bush administration has taken a leading role in supporting international climate change policy. Most of the objections among Democrats and Republicans alike concern the purported costs of GHG reduction generally – and the Kyoto Protocol specifically – to the United State's economy, as well as the lack of GHG targets for developing countries like China and India, who will soon produce a large share of the world's annual GHG emissions. Much of the political debate in the United States in the 1990s was tilted by special interests (e.g., the coal and automobile sectors), a very well-financed lobbying campaign (e.g., the Global Climate Coalition) and the lack of attention to this issue by American citizens experiencing an economic boom. Nevertheless, the inability of the United States to take leadership in this area has diminished our international credibility worldwide, particularly among many OECD nations who are beginning to implement comprehensive climate policies (e.g., Canada and Britain).

By 2003, much of the leadership in the United States on climate change is coming from collaborations between the non-profit sector and the private sector. For example, The Pew Center on Global Climate Change has served as an influential forum for corporate and non-profit leaders to objectively explore the environmental and economic risks and uncertainties associated with climate change. In January 2003, the Chicago Climate Exchange began to provide a market for the voluntary trading of GHG emissions: its founding members include Dupont, Ford Motor Company, and International Paper.

I.2 The State and Local View

I.2.1 Potential climate impacts on Vermont

Climate change is clearly a global issue, but its impacts will be decidedly local. Admittedly, the uncertainties associated with regional predictions of the consequences of climate change are higher than the uncertainty in global predictions. Despite these uncertainties, the

EPA has reported some of the expected consequences for the state of Vermont, building on model studies undertaken by the IPCC and other organizations.[2] Among others, the EPA indicates the following outcomes:

- By 2100 temperatures in Vermont could increase by ~ 4°F.
- Precipitation will increase by 5-20% in summer and fall and by 10-50% in winter.
- Higher temperatures will increase the incidence of heat-related illnesses and deaths, particularly among the elderly.
- Concentrations of ground-level ozone, one of the major components of smog, will increase by a minimum of 4%, leading to increased rates of asthma, respiratory disease, respiratory allergies, and eye allergies.
- Incidence of Lyme disease and other tick-borne diseases will increase.
- The incidence of harmful algal blooms in lakes and rivers will increase, with a corresponding increase in cryptosporidiosis and giardia.
- Changes in the timing and accumulation of snow could affect skiing conditions in positive and negative ways, such as the timing and length of season and snow depth.
- Increased rainfall could exacerbate levels of pesiticdes and fertilizers in runoff from agricultural lands.
- A preliminary study of the impact on Vermont's major crops, silage and hay, is summarized in Figure I.1.
- Maple-dominated hardwood forests will tend to give way to oak and hickory, dramatically changing the fall foliage colors and significantly impacting the maple sugar industry. Where maples remain, sap will tend to run earlier and with shorter duration than it does currently.
- Spruce-fir forests, already at the southern end of their extent, will be degraded, with significant impacts on songbird habitat.

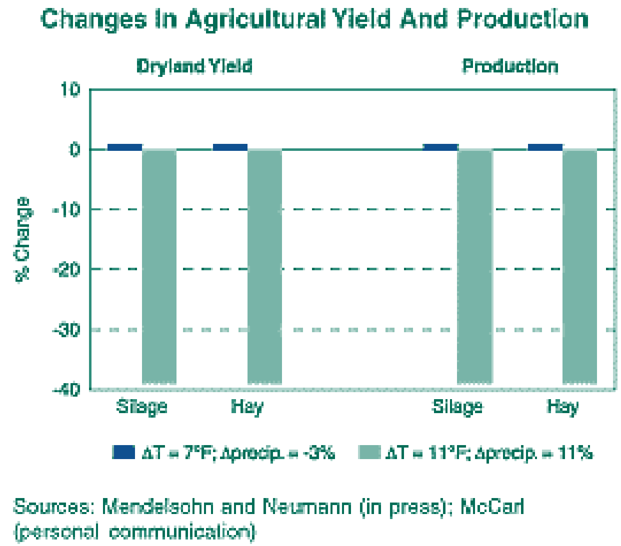


Figure I.1. Regional Impact on Silage and Hay Crops.[2]

Even acknowledging the uncertainties associated with these projections, it is clear that the state of Vermont will face significant challenges as a result of climate change. The effects listed above correspond to the delayed result of the last ~200 years of human-induced greenhouse gas emissions. As fossil fuel use and human GHG emissions continue, the consequences for Vermont's natural environment and quality of life will only increase.

I.2.2 Current Climate-Related Initiatives: New England and Vermont

Here in New England, Middlebury is in good company: many regional institutions are making significant steps towards reducing GHG emissions. For example:

- The New England Governors and Eastern Canadian Premiers recently approved a Climate Change Action Plan, which calls for the New England states and the Eastern Canadian provinces to work together to reduce greenhouse gas emissions by cutting emissions from power plants, increasing the use of renewable energy sources, and energy efficiency and conservation. The short-term goal of the Governors and Eastern Canadian Premiers is to reduce regional greenhouse gas emissions to 1990 levels by 2010 and by 10 percent below 1990 levels by 2020. The long-term goal is to reduce emissions to a level that eliminates any dangerous threats to the climate - reductions 75 to 85 percent below current levels. The governors and premiers are calling on academic institutions like Middlebury College to take the lead in implementing this plan.
- The Tufts Climate Initiative is "steering Tufts towards a cleaner energy path." Launched under the sponsorship of the Tufts Institute of the Environment (TIE), TCI's early, rapid progress has been advanced through the collaboration of the entire Tufts community and the participation and funding of the Henry P. Kendall Foundation. The TCI staff includes two faculty members, one part-time project manager, and several graduate student research assistants.
- The 10% Challenge is a voluntary program, developed by business and government leaders in Burlington, to help households and businesses reduce greenhouse gas

emissions by at least ten percent. The 10% Challenge provides the tools and the information necessary to conserve energy at home and at work by following these steps: 1. Signing up online**.** 2. Calculate personal Emissions 3. Pledge to Take Action! The Town of Middlebury, lead by Representative Steve Maier, is exploring the possibility of starting a local version of The 10% Challenge.

I.3 The Middlebury Campus

I.3.1 History of the Project at Middlebury

The focus on climate change has intensified on the Middlebury Campus over the last four years. Many national leaders on climate change issues have visited the Middlebury College campus in the last four years, thereby helping our community to learn more about the urgency of this global challenge. They include:

- Ross Gelbspan, the leading journalist in this field, and author of *The Heat is On*
- Bill Moomaw, Professor of International Environmental Policy at the Fletcher School of Law and Diplomacy at Tufts University and the chair an international working group of scientists for the IPCC.
- Jonathan Lash, the Director of the World Resources Institute.
- Steven Percy, former CEO of BP America and a member of President Clinton's council on sustainable development.

In addition, much of the awareness on this issue has been homegrown. Professor Rich Wolfson of the Physics Department, through regular campus-wide talk and the establishment in 2001 of a successful new course, PH/ES 240 - Global Climate Change, has taken the lead on teaching the campus community about this issue. Bill McKibben, the influential author of The End of Nature, has been a Visiting Scholar in Residence since 2001. And Middlebury students, in countless forums such at *The Campus* newspaper, environmental clubs, and their own academic work, have taught the entire community about why and how we must act.

In September 2001 members of Middlebury College's Environmental Council created the Carbon Neutral Subcommittee to research and assess the possibilities for Carbon Neutrality on the Middlebury College Campus. Building on work begun by the Climate Change committee of the year before – including Amy Seif (the former Environmental Coordinator), Peter Ryan (Assistant Professor of Geography) and selected students -- the Carbon Neutral group spent the year collecting data, and discussing ways in which the Middlebury College community could begin to reduce its Greenhouse Gas emissions, both in the short and long term. An emissions inventory, which compiled data from Middlebury College's contribution of CO_2 into the atmosphere over a ten-year period, was a major focus of the committee. With this information, the group was able to focus on such areas as transportation, and the need for a reduction in energy consumption. The committee also looked at ways in which to bring the idea of Carbon Neutrality and the issues surrounding it to the campus, both in and outside the campus.

During February break of 2002, six members of the Carbon Neutral Subcommittee were privileged to attend the College Climate Response organizational meeting, held at Lewis and Clark College in Portland, Oregon. This meeting brought together over 25 colleges and universities from across the country who are engaged in reducing their greenhouse gas emissions, thereby decreasing their carbon footprint. The conference worked to promote greenhouse gas inventories on college campuses, to provide a network for sharing campus emission reduction strategies, and ncourage students faculty and administrators to commit funds to purchase offset packages to supply campus demands. After the conference, and in consultation with the other members of the subcommittee, Professors Lori Delnegro (Chemistry Department) and Jonathan Isham (Economics Department and Program in Environmental Studies) proposed to develop and teach a Winter Term course: ES 010 "The Scientific and Institutional Challenges of Becoming Carbon Neutral," during Winter Term (January) 2003.

In September 2002, six members of Carbon Neutral Subcommittee attended a follow-up conference at Skidmore College in Saratoga Springs, New York, which reunited many of the participants from the first conference while adding new institutions at the beginning of the process. At this conference, Middlebury was asked to present the results of its greenhouse gas emissions inventory and to report on the steps that have been taken after its completion.
On October 28, 2002, Middlebury College's Community Council – building on the campus-wide momentum on this issue – unanimously approved a "Carbon Reduction Initiative" (CRI), which is copied here in full:

> ***Proposal:***
> *The Environmental Council urges the College to support the creation and development of an initiative to reduce greenhouse gas emissions at Middlebury College by the amount stipulated by the Conference of New England Governors and Eastern Canadian Premiers or by an amount agreed to by the working group.*
>
> *In order to achieve this goal, we propose the formation of a working group comprised of students, faculty, staff, and administrators. These representatives should, at minimum, include*
>
> - *students representing each of the five commons and appointed by the Student Government Association*
> - *faculty members from at least 3 divisions and appointed by the Faculty Council*
> - *4 staff or administrators appointed by the Staff Council, 3 of whom should represent various departments including Facilities Planning, Facilities Management, Purchasing, Dining Services, and the Treasurer's Office*
> - *Nan Jenks-Jay (Director of Environmental Affairs) and the Vice President for Finance and Administration/Treasurer or his/her delegate as Co-Chairs, and Connie Leach Bisson (Campus Sustainability Coordinator) as staff to the working group.*
>
> *This working group, using data presented to it by the Environmental Council, should be charged with (1) identifying a specific carbon reduction goal for the College, (2) developing a specific carbon reduction plan that outlines the steps necessary to achieve said goal, and (3) reporting to the Environmental and Community Councils on progress made at the end of each academic year.*

It is for the CRI working group that this report has been prepared by the students of ES 010.

I.3.2 Emissions Inventory and Implications

From Fall 2001 through Fall 2002 a campus emissions inventory was undertaken by Doug Dagan ('03) with oversight by Connie Bisson (Campus Sustainability Coordinator) and Lori Del Negro (Visiting Professor of Chemistry). A brief summary of the findings of that inventory is presented here, to provide context as well as basis for the sample calculations of reductions and offsets presented in this report.

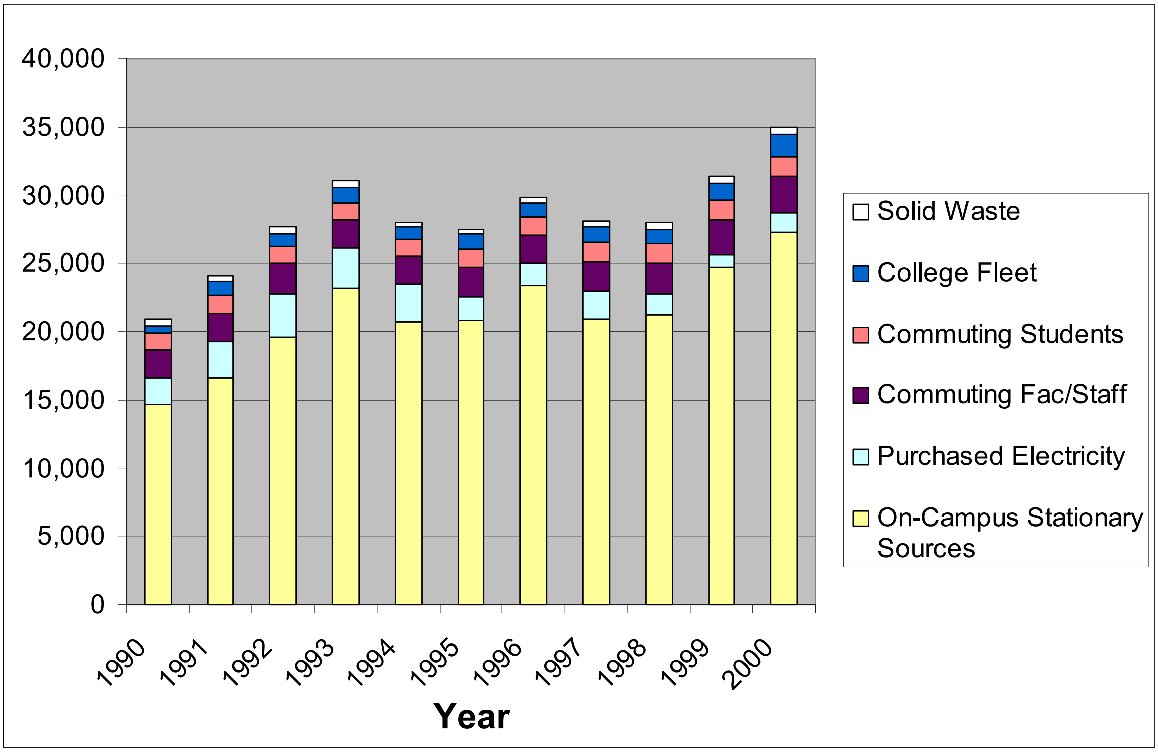
The inventory was performed using a calculator developed by Clean Air-Cool Planet[2], although some of the conversion factors have been modified from their original version to better represent the infrastructure and/or fuel mix specific to Middlebury College. The calculator is divided into eight input categories as follows: On-campus stationary sources (fuels used in stationary boilers or furnaces for space heating and cooling and domestic hot water), Electricity, Steam (if purchased from an external source), College Fleet, Commuters (faculty, staff, and students), Animals (livestock), Waste, and Refrigeration. Because Middlebury College does not keep livestock animals, purchase steam, or use fluorocarbon refrigerants, the Steam, Animals, and Refrigeration categories had no inputs. A table of the remaining five inputs and associated carbon dioxide equivalent (CDE) emissions for the year 2000 is provided in Table I.1 below, and Figure I.1 shows the trends in the emissions inventory for the years 1990 – 2000.

Table I.1. Emissions inventory for the year 2000.[3]

Emission Category	*Input type*	*Input amount*	*MTCDE*[a]
On-campus Stationary Sources	Residual Oil (#5,#6)[b]	1,700,000 gallons	22,000
	Distillate Oil (#1-#4)[c]	391,000 gallons	5015
	Propane	40,800 gallons	295
Electricity	CVPS Mix[d]	19,900,000 kWh	1416
College Fleet	Gasoline	70,200 gallons	747
	Diesel	71,500 gallons	830
Commuters	Faculty/Staff[e,f]	6,000,000 miles	2700
	Students[e,g]	3,400,000 miles	1495
Waste	Landfilled Waste[h]	626 tons	640

[a] Metric tonnes carbon dioxide equivalent emissions. [b] Only #6 oil used on campus. [c] Primarily #2 oil used on campus. [d] CVPS mix 2000: 34.4% hydroelectric, 41.1% nuclear, 2.7% residual oil, 21.8% renewables. [e] Average mileage assumed to be 24 mpg, equal to the national average. [f] Single round-trip commute estimated using average distance from origin ZIP code to destination ZIP code. [g] Single round trip to and from campus estimated using average distance from main city in home state to destination ZIP code. [h] Conversion factor assumes no methane recovery or cogeneration.

Figure I.1. Metric Tonnes Carbon Dioxide Equivalents Emitted: 1990 - 2000[3]



For the purposes of this course, the emissions associated with the College Fleet and Commuters emissions categories were combined, to produce the following four (4) sectors responsible for the campus CDE footprint: Space Heating and Cooling (includes domestic hot water), Electricity, Transportation, and Solid Waste. Within each of these sectors, students investigated a variety of options for reducing the emissions produced (e.g. through efficiency measures, education, and conservation), switching to "cleaner" fuels and technologies that inherently produce fewer CDE emissions, and offsetting those emissions that can't be eliminated through investments in projects off-campus that would reduce emissions elsewhere.

The Clean Air-Cool Planet calculator accounts for not only the carbon dioxide emissions associated with combustion and use of the various fuels, but also the associated emissions of methane and nitrous oxide. Emissions of these gases are converted to "equivalent" carbon dioxide by multiplying their emissions by the appropriate Global Warming Potential (GWP; 21 for methane, 310 for nitrous oxide). Hence, campus emissions are reported as metric tonnes of carbon dioxide equivalents (MTCDE).

In addition to the direct emissions produced on site, the Clean Air Cool Planet calculator also includes upstream emissions associated with production and transport of a particular fuel. The only exception to this inclusion of upstream sources is in the solid waste sector, for which each product purchased, used, and discarded as part of campus activities may have dramatically different emissions associated with its manufacture and delivery. Once again, while there are many arguments for and against including upstream emissions, the emissions and emissions reductions presented in this report follow the format of the Clean Air Cool Planet calculation for the sake of consistency.

The conversion factors used in the emissions inventory include many factors: efficiencies, oxidation percentages, heat values for particular fuels, etc. For the sake of easy comparisons, all of the complex, multi-step conversions have been combined and compiled in

Table I.2. For the full detail of the conversion, refer to the full CACP calculator or the file "CO2 Conversion Factor.xls".

As both Table I.1 and Figure I.1 demonstrate, the emissions associated with Space Heating and Cooling are by far the dominant contribution to the total inventory, amounting to ~78% of the total. Thus, fundamental changes in fuel sources and efficiencies in this sector are likely to have the largest impact on campus emissions. The second largest sector, once its components are combined, is Transportation (~ 16%). Strategies within this sector are inherently complex given the many small point sources involved, most of which controlled by individual choice rather than institutional policy. In general, this added complexity leads to a much higher cost per tonne of CDE reduced, which might tend to emphasize measures in other sectors. However, as the most visible representation of campus energy use and responsibility, the Transportation sector has the greatest potential to "advertise" Middlebury's commitment to the climate issue, or, conversely, to convey the impression that Middlebury is "looking for the easy way out." Thus, in terms of public relations, social, and other non-climate environmental benefits, the Transportation sector remains one of the most important in any carbon neutral plan.

Both the Electricity and Solid Waste sectors have relatively low contributions to the total inventory (~ 4% and ~ 2%, respectively), but present unique opportunities to have a large impact on the total CDE reduction. In the case of electricity, the relatively low CDE intensity of the CVPS electricity mix leads to a relatively small CDE impact, even with large reductions in consumption. However, electricity is the most expensive fuel purchased by the college,

Table I.2. Conversion Factors used to convert inputs to MTCDE[a].

Sector	*Fuel Source*	*Conversion*	*Conversion units[b]*	*Comments*
Space Heating and Cooling				
	Natural gas	0.0080	MTCDE/therm	* These conversion factors represent the complete conversion, including both direct and upstream emissions, of carbon dioxide, methane, and nitrous oxide.
	Propane	0.0072	MTCDE/gallon	
	Residual oil (#5,#6)	0.0130	MTCDE/gallon	
	Distillate oil (#1-#4)	0.0128	MTCDE/gallon	
	Coal	1.8536	MTCDE/Imperial ton	
	Incinerator	0.0442	MTCDE/MMBTU	
	Natural gas	0.0798	MTCDE/MMBTU	* These conversion factors are the most useful for comparing the efficiency of energy extraction with respect to its direct and upstream equivalent carbon dioxide emissions.
	Propane	0.0861	MTCDE/MMBTU	
	Residual oil (#5,#6)	0.0926	MTCDE/MMBTU	
	Distillate oil (#1-#4)	0.0926	MTCDE/MMBTU	
	Coal	0.1002	MTCDE/MMBTU	
	Incinerator	0.0440	MTCDE/MMBTU	
	Natural gas	0.1000	MMBTU / therm	* These conversions allow comparison of fuels on a "per unit energy" basis.
	Propane	0.0840	MMBTU / gallon	
	Residual oil (#5,#6)	0.1400	MMBTU / gallon	
	Distillate oil (#1-#4)	0.1387	MMBTU / gallon	
	Coal	18.4950	MMBTU / Imperial ton	
	Incinerator	1.0050	MMBTU / MMBTU	
Electricity				
	Coal	1.086E-03	MTCDE/user kWh	* User kWh is used because conversion includes correction for 8% transmission losses. Conversion also includes efficiency of electricity production (ranging from 34-41%) and accounts for both direct and upstream emissions of carbon dioxide, methane, and nitrous oxide associated
	Residual Oil (#5, #6)	9.992E-04	MTCDE/user kWh	
	Distillate Oil (#1-#4)	9.992E-04	MTCDE/user kWh	
	Natural Gas	7.138E-04	MTCDE/user kWh	
	Nuclear	1.074E-04	MTCDE/user kWh	
	Hydro	0.000E+00	MTCDE/user kWh	

	Renewables	0.000E+00	MTCDE/user kWh	with the use of each fuel.
	CVPS 2000 Mix	7.110E-05	MTCDE/user kWh	* 2000 mix was 41.1% nuclear, 34.4% hydro, 21.8% renewables, 2.7% #6 fuel oil.
		3412	kWh/MMBTU	
Transportation				
	Natural Gas	0.0112	MTCDE/therm	* These conversion factors are based on quantity of fuel consumed and therefore do not account for mpg for a given vehicle.
	Gasoline	0.0131	MTCDE/gallon	
	Diesel	0.0123	MTCDE/gallon	
Solid Waste				
	Landfill:			
	w/ no CH_4 recovery	0.9282	MTCDE/wet ton waste	* Landfill factors based on CH_4 and CO_2 emissions from landfill decomposition. CF for incineration includes only CO_2 emissions from waste combustion.
	w/ flaring	0.2500	MTCDE/wet ton waste	
	w/ electric generation	0.1071	MTCDE/wet ton waste	
	Incineration	0.4850	MTCDE/wet ton waste	

[a] Metric tonnes carbon dioxide equivalent emissions. [b] MMBTU = million British Thermal Units; kWh = kilowatt hour

amounting to $1,800,000.00 in the year 2000 (~$0.09/kWh, or $307.00/MMBTU). Due to the high cost of electricity relative to other energy sources, even small reductions in electricity consumption lead to large cost savings to the college. These cost savings, therefore, might help to pay for those strategies that will cost the college money to implement, but which create large reductions in the footprint.

Middlebury College already has in place recycling and composting policies that help to minimize the emissions associated with solid waste. Conversion factors associated with both recycling and composting are limited to those arising from transportation of materials from one place to another, or from active aeration of a compost system. Because compost systems maximize aerobic decomposition and minimize anaerobic decomposition, emissions of methane from compost are negligible relative to those from landfills. While carbon dioxide is a necessary product of decomposition, even in composting, these emissions are not included in the Clean Air Cool Planet calculator because they are assumed to mimic “natural” decomposition and do not accelerate the emission of CO_2 to the atmosphere (see discussion of carbon neutral, section I.4.1, below). Similarly, although the recycling of post-consumer materials involves additional inputs of energy, with associated CDE emissions, these emissions are considered outside the campus boundary and are not included in the inventory. As a result, the 640 MTCDE associated with the solid waste sector represent only those emissions arising from landfilled waste. Because more than 50% of the college waste stream is either recycled or composted, this figure is already less than half of what it could be. In looking for ways to further reduce the emissions associated with Solid Waste, the college has the opportunity to improve its operation in a sector for which we are already nationally recognized as a leader.

A fifth sector, Sequestration, looked at options that would increase the rate at which carbon dioxide is removed from the atmosphere, through activities on campus and elsewhere. The current Clean Air-Cool Planet calculator does not account for any terrestrial carbon reservoirs and sinks (forests, agricultural soils, etc.) that may exist on a given campus. There are many arguments for and against the practice of “crediting” an inventory for its reserves, as the negotiations related to the Kyoto Protocol have demonstrated. In this report we have chosen to abide by the guidelines provided by the inventory calculation. As a result, any enhancements of existing sinks would be counted as offsets to the total emissions after the fact, rather than as part of the initial inventory.

I.4 Our goal: why Carbon Neutral?

I.4.1 What is carbon neutral? (Sources/Sinks, etc.)

As noted above in Section I.3.1: Emissions Inventory and Implications, the impact of human activities on the global climate is not limited to emissions of carbon dioxide. Even if we focus solely on the combustion of fossil fuels as a source of greenhouse gases, it is clear that emissions of methane and nitrous oxide enhance the larger emission of CO_2. In some industries, it is the emission of various fluorocarbons or sulfur hexafluoride that has the greatest potential to influence the climate. Yet, the most difficult and fundamental change that human society will have to make if we wish to minimize our impact on climate will be to significantly reduce, if not eliminate, the emission of carbon dioxide. Hence, the emissions inventory refers to our combined footprint in terms of "carbon dioxide equivalents", and many organizations concerned with the climate change issue have begun to talk in terms of "carbon pollution." In this context, the term most commonly used to describe a net climate impact of zero is "carbon neutral".

The scientific basis for the concept of carbon neutrality has to do with the dynamic balance that describes a compound's atmospheric concentration. A change in the atmospheric concentration of any compound ($\triangle C$) is described by six terms as follows:

$$\triangle C = \mathbb{T}_{in} + \mathbb{P} + \mathbb{S}ources - (\mathbb{T}_{out} + \mathbb{L} + \mathbb{S}inks)$$

where $\mathbb{T}_{in}$ is the transport of that compound into a specific region of the atmosphere, $\mathbb{T}_{out}$ is the transport of that compound out of that region of the atmosphere, $\mathbb{P}$ represents chemical production of that compound in the atmosphere, $\mathbb{L}$ represents chemical loss, $\mathbb{S}$ources are emissions of the compound to the atmosphere, and $\mathbb{S}$inks are removal processes. This equation can be greatly simplified for carbon dioxide in the context of climate impact because CO_2 is relatively long-lived and more or less uniformly distributed in the lower atmosphere. Hence, the impact of the $\mathbb{T}_{in}$ and $\mathbb{T}_{out}$ terms, which account for concentration gradients within the atmosphere, become negligible. Similarly, the chemical production and chemical loss of CO_2 in the atmosphere are relatively balanced processes and tend to be slow relative to the activity of sources and sinks. As a result, for CO_2 the equation above simplifies to two essential terms:

$$\triangle CO_2 = \mathbb{S}ources - \mathbb{S}inks.$$

Given this simplified equation, it is easy to see that in the pre-industrial period when CO_2 concentrations were roughly constant, the sources and sinks for CO_2 must have been of equal magnitude, i.e. balanced. Conversely, the exponential rise in the atmospheric concentration of CO_2 that has characterized the last two centuries indicates an exponential increase in the sources of CO_2, outpacing any increases in CO_2 sinks.

The explanation for this is easily correlated with the exponential growth in the combustion of fossil fuels as an energy source for human activities. CO_2, like all atmospheric compounds, is transported through the environment via identifiable cycles. The terrestrial biosphere (forests, soils, microbes, algae, etc.) acts as a sink for CO_2, drawing it out of the atmosphere through photosynthesis and storing carbon in the form of organic material in living systems. The biosphere also acts as a source of CO_2, releasing it back to the atmosphere through respiration and decomposition. The balance of these processes determines the amount of carbon "stored" as living material and the time constant for CO_2 exchange in the biospheric-atmospheric cycle, on the order of decades to a century.

Similarly, CO_2 has geological sources and sinks that define the geologic-atmospheric cycle, which has much longer time constant, on the order of millennia to millions of years. These geological sources and sinks tend to be much slower than biological processes, and the reservoir for carbon storage is much larger. Fossil fuels, comprising only a small fraction of the geological reservoir, have natural formation and destruction rates that match this long geological time constant. Human activities have accelerated the emission rate of fossil fuels to a time constant of a few years, without accelerating the action of geologic sinks. In fact, nearly half of the CO_2 emissions arising from fossil fuel combustion have been taken up by increasing biospheric and oceanic sinks, but the sources still outweigh the sinks and the CO_2 concentration increases.

For the atmospheric CO_2 to stabilize at some concentration in the future, there are two possible strategies: 1) reduce the sources of CO_2 until they are balanced with existing sinks, or 2) increase the sinks for CO_2 until they are balanced with sources. In either of these cases, once (Sources – Sinks) = 0 the concentration of CO_2 in the atmosphere will cease changing. If sources are reduced without any change in sinks, CO_2 will stabilize at an atmospheric concentration considerably larger than today's, and the longer it takes to achieve that balance, the higher that concentration will be. The same result would be achieved if sinks were increased with no change in sources. For the concentration of CO_2 in the atmosphere to decrease, sinks will have to outweigh sources for some period of time.

Therefore, the concept of carbon neutrality is simply this: if the sources and sinks of CO_2 are equivalent, the concentration of CO_2 should not change, hence, there will be no additional CO_2 in the atmosphere to further contribute to climate change. A government, business, campus, or individual that is carbon neutral is also climate neutral, and is helping to stabilize CO_2 and the global climate.

I.4.2 "Carbon Neutral" as a target.

In the context of climate change there are any number of potential emissions reductions targets that could be established. As noted in Section 1.2.2., the city of Burlington has adopted a 10% Challenge, the New England Governors and Eastern Canadian Premiers have challenged colleges and universities to strive for compliance with the terms of the Kyoto Protocol (which in the U.S. amounts to emissions reductions of ~ 30-35%), others may opt for more ambitious targets of 50%, or, in fact, carbon neutrality – net zero emissions. "Carbon neutral" was chosen as the target for the students of ES 010 for several important reasons.

First, based on the preceding discussion in Section 1.4.1, only by achieving carbon neutrality at the global scale will the concentration of carbon dioxide in the atmosphere stabilize. The targets of the Kyoto Protocol, which many governments and industries regard as too severe, will do little more than incrementally slow the upward climb of carbon dioxide concentrations and, therefore, global temperature.

Second, rather than speaking strictly of percentage reductions in emissions, the concept of carbon neutrality lends itself to a broader discussion of both sources and sinks as part of an ongoing policy. When discussing percentage reductions in emissions, an organization must decide when and where to set its baseline, and all discussions must be placed in the context of that baseline. The discussion becomes much more complicated, however, as an institution grows in size, adds new buildings, changes its operations, etc. In contrast, the concept of carbon neutrality evolves naturally with an institution, requiring only that in any given year sources and sinks are balanced.

Third, in the context of the class it was important to set the most ambitious goal possible to see the greatest possible result. For example, had we asked the class to investigate ways to reduce our footprint by 10%, the Space Heating and Cooling sector would have found sufficient reductions by replacing windows and resetting thermostats and would never have considered more massive possibilities like converting the campus heating plant to use biomass as its fuel. While many of the "big" strategies may not be feasible in the short term, only solutions at this level will truly mitigate the human impact on climate. There is certainly added value in acknowledging and addressing the full scope of the problem.

Finally, while the populations of many colleges and universities have begun to address the climate issue, most are attacking the problem in a piecemeal fashion – eliminating wasted electricity, investing in renewable sources of electricity, improving the energy efficiency of new buildings, etc. While these are all laudable efforts, in many cases they overlook the synergistic relationships and potential cost savings of attacking the issue holistically. Establishing a goal of carbon neutrality forces those working toward it to keep checking the "big picture" to find ways to minimize cost and effort and maximize results. A carbon neutral approach is clearly the way to demonstrate leadership in the climate issue.

While carbon neutrality is, admittedly, a more ambitious target than many, it does not appear to be unattainable. Based on the year 2000 inventory of 35,000 MTCDE, and a price for offsets of $8/tonne, Middlebury College could simple spend $288,000.00 to entirely mitigate its climate impact. This figure amounts to about 0.25 % of the college's annual budget. We certainly do not advocate having the college "buy its way out" of the climate issue, particularly when there is money to be saved by implementing energy saving measures, but it seems clear that carbon neutrality is within the realm of possibility.

I.5 Using the logical framework to organize carbon neutral strategies

I.5.1 Introduction to the logical framework

For the design of this report, we have adopted the 'logical framework,' a management tool frequently used by project managers for designing, implementing and monitoring a complex project. To achieve a project <u>goal</u>, the logical framework builds a hierarchy of <u>objectives</u>, <u>activities</u> and <u>tasks</u>. Take the example of a health project in a local region in the developing world. In order to achieve the project <u>goal</u> -- reducing water borne diseases in the region by 50 percent -- the project team must meet certain <u>objectives</u>. In this case, for example, the objectives would be to: (a) increase the availability of clean water by 75 percent; and (b) educate 90 percent of the local population about water-borne diseases. Each of these objectives, in turn, would be broken down into <u>strategies</u> -- that is, the project 'deliverables.' For the first objective, the first strategy might be to identify all sources of clean water in the region; subsequent strategies would include the installation and maintenance of water systems. For the second objective, the first strategy might be to design an education campaign for all local women about water-borne disease; the subsequent strategies would be to implement and evaluate this campaign. Finally, each strategy is made up of <u>tasks</u>, the day-to-day operations of the project team: contracting the engineers, consulting with local educators, and so on.

I.5.2 The logical framework for this carbon neutral plan

Following this framework, our design of a carbon neutral plan for Middlebury College is broken down into a objectives, activities and tasks that mutually support the ultimate goal of the project. The goal of this plan   The objectives in each sector (as detailed in the next five chapters) are built around the following three principles:

- Reducing our GHG emitting activities
- Replacing dirty technologies with greener technologies
- Offsetting what we can't eliminate.

Each objectives is in turn comprised of strategies: for example, 'lowering the campus thermostat set points' (space heating and waste) and 'switching electricity providers' (electricity). It is these strategies, summarized in Appendix Table 1, that are the core of each of the next five chapters. Finally, each strategy is followed by a set of initial tasks (labeled 'getting started'). These are the first sets of actions that stakeholders in the Middlebury College community can take to begin to achieve the strategy.

I.6 The ranking of carbon neutral strategies

To guide the members of the CRI working committee and the decision makers at Middlebury College, we felt that it was important to prioritize the many strategies that were identified in each of the five sectors. Accordingly, we developed a ranking system based on three criteria:

- Average annual benefit or cost

  As detailed in the next five chapters, we calculated, whenever possible, the average annual benefit (+) or cost (-) of each strategy. For each strategy, this was calculated by adding the start-up cost to the stream of net benefits, and then dividing this figure by the number of years of the strategy. (It should be noted that for some immediately attainable strategies – for example, the reduction of thermostat set points – there are virtually no start up costs, and the strategy has a net benefit that could conceivably be realized year after year. In a small set of long-range strategies, by contrast, the start-up costs are substantial – for example, converting a boiler to biomass – and the annual savings are confined to a specific lifetime.)

- Other benefits and costs

  We also felt that it was important to acknowledge the potentially large other benefits and cost associated with each strategy. These include environmental, social, and public relations benefits. Take the case of the preservation of local forests (in the sequestration sector). Clearly, the substantial environmental benefits (restoration of wilderness), social benefits (job creation among local foresters), and public relations benefits (good image for the college) of this strategy should be taken into account.

- Uncertainty and risk

  Many of our strategies are virtually certain to be effective, and entail very little risk (again, the reduction of thermostat set points). Others (installing a methane capture facility at the Moretown landfill) have greater uncertainties and risk. We felt that these (in some cases) vastly different levels of risk and uncertainty should also figure in our ranking system.

In order to combine these three criteria, we first developed three sub-indices. For 'other benefits and costs' and 'uncertainty and risk,' we used subjective rankings from 1 – 7, where 7 represented very high other benefits and very low uncertainty and risk, respectively.

For average annual benefits and costs, we needed to create a comparable index that was not unduly skewed by the small set of strategies with very high benefits (for example, fully adopting biomass boilers.) We ultimately decided to: (a) assign a 7 to all annual benefits with a value of $70,000 or greater; and (b) divide all lower annual benefits (or costs) by $10,000. This allowed us to create a 'financial subindex' with an upper bound of 7 (comparable to the other two sub-indices) and no lower bound.

We then created an aggregate 'summary index,' the weighted average of the three sub-indices. Since we felt that the financial considerations were most important to assure the long-term viability of a carbon neutral policy, the weights were calculated as follows:

Summary index = 0.50 * 'financial index'
+ 0.25 * 'other benefits and costs index
+ 0.25 * 'uncertainty and risk index'

(Modifications to the weights did not dramatically change the overall rankings of the strategies). Overall, we felt that this was a reasonable method for integrating other important criteria with the critical financial criteria.

I.6 The ranking of all of the strategies in this report

Table I.1 presents a summary of all of the strategies summarized in this report. The table serves two functions. First, it compactly summarizes the diverse strategies across the five project sectors. Second, it illustrates the relative rankings of all of the strategies, using the summary index described in the previous sub-section. After looking at this table, the reader can then find the details for each of the strategies in the next five chapters, from which the data in this table has been assembled.

The respective columns in Table I.1 are as follows:

(First part of table – **strategy description** and **ranking of strategies**)

- <u>Sector</u>, <u>report heading</u>, and <u>strategy name</u> (columns 1 – 3) introduce the strategies.

- Annual Tonnes CDE (column 4) is the estimated annual tonnes of CDE for the strategy.
- Index rank (column 5) is the rank -- from 1 to 60 -- of the strategy, based on the summary index
- Summary index (column 6) is the weighted index described in sub-section I.5.3.
- Financial index, Other costs and benefits index, and Uncertainty index (columns 7 – 9) are the sub-indices described in sub-section I.5.3.

Table VII.1: Summary of Carbon Reduction Strategies (part 1)

Strategy description					Ranking of strategies			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sector	***Report heading***	***Strategy name***	***Annual tonnes CDE***	***Index rank***	***Summary index***	***Financial index***	***Other costs and benefits index***	***Uncertainty index***
Heating/Cooling	II.3.1.a	Thermostat setpoints	459	12	4.0	3.2	2.5	7
Heating/Cooling	II.3.1.b	Half biomass	11,000	9	5.1	7.0	3.5	3
Heating/Cooling	II.3.1.b	All biomass	22,000	10	4.6	7.0	3.5	1
Heating/Cooling	II.3.1.c	Passive solar design		15	3.4	0.0	7	6.5
Heating/Cooling	II.3.1.d	Heating education campaign	23	23	2.8	0.1	7	4
Heating/Cooling	II.3.1.e	Window replacement	220	18	3.3	0.5	6	6
Heating/Cooling	II.3.2.b	100 low-flow shower valves	50	26	2.7	0.4	4	6
Heating/Cooling	II.3.2.a	Solar water heating	5	33	2.5	0.3	4.5	5
Heating/Cooling	II.4.1	Natural gas support	3,000	11	4.5	7.0	3	1
Electricity	II.3.1.a	10% residential electricity conservation education	80	8	5.3	7.0	3.5	3.5
Electricity	II.3.1.b	3000 CFL bulbs (no rebate)	6	32	2.5	0.6	4.5	4.5
Electricity	II.3.1.b	3000 CFL bulbs (rebate $3)	6	30	2.6	0.7	4.5	4.5
Electricity	II.3.1.c	Computer use education	29	14	3.6	3.7	3.5	3.5
Electricity	II.3.1.d.	Vending Misers (30% reduction)	3	28	2.6	0.3	3	7
Electricity	II.3.2.a	Advocate renewables (5% fossil fuel reduction)	27	5	5.5	7.0	4	4
Electricity	II.3.2.a	Advocate renewables (10% fossil fuel reduction))	81	5	5.5	7.0	5	3
Electricity	II.3.2.a	Advocate renewables (15% fossil fuel reduction))	134	5	5.5	7.0	6	2
Electricity	II.3.2.b	Solar panelling	1	25	2.7	0.0	5	6
Electricity	II.3.3	Electricity offsets (Native Energy)	36,000	50	-10.9	-28.8	7	7
Electricity	II.3.3	Electricity offsets (ReGen)	36,000	53	-81.1	-169.2	7	7
Electricity	II.3.3	Electricity offsets (Addison County Schools)	36,000	52	-59.5	-126.0	7	7
Electricity	II.4.2	Switch to GMP under deregulation	61	4	5.6	7.0	5	3.5
Transportation	IV.3.1.a	Limit student vehicles	250	49	-2.9	-12.8	7	7
Transportation	IV.3.1.b	Rideboard incentives	100	38	2.2	-0.1	5	4
Transportation	IV.3.1.c	Employee commuting incentives/fees	130	46	-1.1	-7.7	7	4
Transportation	IV.3.1.d	Reduce campus fleet use	150	29	2.6	0.8	5	4
Transportation	IV.3.2.a	Replace Gators and golf carts w/ electric vehicles	71	36	2.3	-0.4	5	5

Sector	Report heading	Strategy name	Annual tonnes CDE	Index rank	Summary index	Financial index	Other costs and benefits index	Uncertainty index
Transportation	IV.3.2.b	Replace gas fleet w/ diesel vehicles	5	16	3.4	0.2	6	7
Transportation	IV.3.3.a	Switch diesel fleet to biofuel	440	41	1.4	-4.2	7	7
Transportation	IV.3.3.b	Charter biofueled coach buses	36	31	2.6	-0.4	7	4
Transportation	IV.3.4.a	Student shuttles	250	37	2.3	-1.5	7	5
Transportation	IV.3.4.b	Collaborate w/ ACTR (public shuttle)	150	19	3.2	-0.2	7	6
Solid Waste	V.3.1.a	Moretown methane capture (no revenue)	12,500	42	1.3	-0.3	4	2
Solid Waste	V.3.1.a	Moretown methane capture (1/2 revenue)	6,250	27	2.7	1.6	5.5	2
Solid Waste	V.3.2.a	Print charge - 10% reduction	19	1	6.5	7.0	6	6
Solid Waste	V.3.2.a	Print charge - 20% reduction	39	2	6.4	7.0	6	5.5
Solid Waste	V.3.2.a	Print charge - 30% reduction	58	3	6.3	7.0	6	5
Solid Waste	V.3.2.b	Online Campus 3000	18	24	2.8	0.3	3.5	7
Solid Waste	V.3.2.b	Online Campus 2000	54	22	2.8	0.9	4.5	5
Solid Waste	V.3.2.b	Online Campus 1000	91	21	3.0	1.6	5.5	3.5
Solid Waste	V.3.2.b	Online Campus 500	108	20	3.1	1.9	6	2.5
Solid Waste	V.3.2.b	Online Campus 0	125	17	3.3	2.2	7	2
Solid Waste	V.3,2,c	Calculate waste - 1% reduction	6	34	2.5	-0.3	3.5	7
Solid Waste	V.3,2,c	Calculate waste - 5% reduction	30	39	2.1	-0.1	4.5	4
Solid Waste	V.3,2,c	Calculate waste - 10% reduction	59	40	2.0	0.2	4.5	3
Solid Waste	V.3,2,d	Catalog Cancel	105	35	2.4	-0.2	5	5
Sequestration	VI.3.1a	Full Emissions Offset-Future Forests	36,000	51	-26.1	-57.6	5	6
Sequestration	VI.3.1a	Full Emissions Offset-American Forests, wildfire	36,000	44	0.0	-5.4	5	6
Sequestration	VI.3.1a	Full Emissions Offset-American Forests, normal	36,000	47	-2.7	-10.8	5	6
Sequestration	VI.3.1a	Full Emissions Offset-Pacific Forest	36,000	47	-2.7	-10.8	5	6
Sequestration	VI.3.2a	Preservation of Local Forests	5,000	13	3.9	2.0	5.5	6
Sequestration	VI.3.2b	Reforestation of Local Harvested Forests	2,800	45	-0.8	-7.5	5	7
Sequestration	VI.3.2c	Agricultural sequestration	789	43	1.1	-2.0	3.5	5

(Second part of table – **financial considerations**)

- Lifetime (column 10) is the estimated years of the strategy. (Note that all of the strategies here have the potential to be reactivated after they expire -- for example, by purchasing another set of Vending Misers after five years. This is of course particularly true for 'renewable' strategies, such as reducing campus fleet use.)
- Payback time (column 11) is (the absolute value of) the ratio of the fixed cost to the net annual benefit. In cases with no fixed cost and a net annual benefit (for example, lowering thermostat set points) this is labeled 'immediate'. In cases with no payback (that is, where the strategy has a net total cost), this is labeled 'none'.
- Fixed cost (column 12) is the start-up cost for the strategy.
- Net variable cost or benefit (column 13) is the difference between the annual variable cost and annual variable benefit.
- Lifetime variable cost or benefit (column 14) is the product of the strategy lifetime and the net variable cost or benefit.
- Total cost or benefit (column 15) is the sum of the fixed cost and the lifetime variable cost or benefit.
- Average total cost or benefit (column 16) is the ratio of the total cost or benefit to the strategy lifetime.
- Total cost per tonne (column 17) is the ratio of the average total cost or benefit to annual tonnes CDE.

Financial considerations

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Strategy name	***Lifetime (yrs)***	***Payback time (years)***	***Fixed Cost (-)***	***Variable cost (-) or benefit (+)***	***Lifetime variable cost (-) or benefit (+)***	***Total cost (-) or benefit (+)***	***Average total cost (-) or benefit (+)***	***Total cost (-) or benefit (+) per tonne***
Thermostat setpoints	50	Immediate	$ -	$ 32,000	$ 1,600,000	$ 1,600,000	$ 32,000	$ 70
Half biomass	50	5.7	$ (1,773,000)	$ 309,300	$ 15,465,000	$ 13,692,000	$ 273,840	$ 25
All biomass	50	2.8	$ (1,795,000)	$ 631,300	$ 31,565,000	$ 29,770,000	$ 595,400	$ 27
Passive solar design	100	None	$ -	$ -	$ -	$ -	$ -	-
Heating education campaign	1	Immediate	$ -	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 52
Window replacement	50	21.4	$ (205,200)	$ 9,597	$ 479,850	$ 274,650	$ 5,493	$ 25
100 low-flow shower valves	50	3.2	$ (14,100)	$ 4,400	$ 220,000	$ 205,900	$ 4,118	$ 82
Solar water heating	30	11.1	$ (50,000)	$ 4,500	$ 135,000	$ 85,000	$ 2,833	$ 567
Natural gas support	30	1.8	$ (300,000)	$ 167,349	$ 5,020,470	$ 4,720,470	$ 157,349	$ 52
10% residential electricity conservation education	3	0.0	$ (3,500)	$ 101,070	$ 303,210	$ 299,710	$ 99,903	$ 1,254
3000 CFL bulbs (no rebate)	10	2.3	$ (17,378)	$ 7,484	$ 72,595	$ 55,217	$ 5,692	$ 963
3000 CFL bulbs (rebate $3)	10	1.1	$ (8,370)	$ 7,484	$ 72,595	$ 64,225	$ 6,621	$ 1,120
Computer use education	1	Immediate	$ -	$ 36,750	$ 36,750	$ 36,750	$ 36,750	$ 1,267
Vending Misers (30% reduction)	5	1.2	$ (4,446)	$ 3,838	$ 19,190	$ 14,744	$ 2,949	$ 983
Advocate renewables (5% fossil fuel reduction)	50	Immediate	$ -	$ 86,035	$ 4,301,750	$ 4,301,750	$ 86,035	$ 3,186
Advocate renewables (10% fossil fuel reduction))	50	Immediate	$ -	$ 86,035	$ 4,301,750	$ 4,301,750	$ 86,035	$ 1,062
Advocate renewables (15% fossil fuel reduction))	50	Immediate	$ -	$ 86,035	$ 4,301,750	$ 4,301,750	$ 86,035	$ 642
Solar panelling	50	None	$ (88,000)	$ 1,700	$ 85,000	$ (3,000)	$ (60)	$ (46)
Electricity offsets (Native Energy)	1	None	$ -	$ (288,000)	$ (288,000)	$ (288,000)	$ (288,000)	$ (8)
Electricity offsets (ReGen)	1	None	$ -	$ (1,692,000)	$ (1,692,000)	$ (1,692,000)	$ (1,692,000)	$ (47)
Electricity offsets (Addison County Schools)	1	None	$ -	$ (1,260,000)	$ (1,260,000)	$ (1,260,000)	$ (1,260,000)	$ (35)
Switch to GMP under deregulation	50	0.0	$ (1,875)	$ 266,889	$ 13,344,450	$ 13,342,575	$ 266,852	$ 4,375
Limit student vehicles	10	None	$ (5,000)	$ (127,500)	$ (1,275,000)	$ (1,280,000)	$ (128,000)	$ (512)
Rideboard incentives	10	None	$ (2,000)	$ (1,000)	$ (10,000)	$ (12,000)	$ (1,200)	$ (12)
Employee commuting incentives/fees	10	None	$ (5,000)	$ (76,500)	$ (765,000)	$ (770,000)	$ (77,000)	$ (592)
Reduce campus fleet use	10	0.6	$ (5,000)	$ 8,300	$ 83,000	$ 78,000	$ 7,800	$ 52
Replace Gators and golf carts w/ electric vehicles	10	None	$ (20,300)	$ (2,000)	$ (20,000)	$ (40,300)	$ (4,030)	$ (57)
Replace gas fleet w/ diesel vehicles	15	8.8	$ (44,000)	$ 5,000	$ 75,000	$ 31,000	$ 2,067	$ 390
Switch diesel fleet to biofuel	10	None	$ (5,000)	$ (41,482)	$ (414,816)	$ (419,816)	$ (41,982)	$ (95)

Strategy name	Lifetime (yrs)	Payback time (years)	Fixed Cost (-)	Variable cost (-) or benefit (+)	Lifetime variable cost (-) or benefit (+)	Total cost (-) or benefit (+)	Average total cost (-) or benefit (+)	Total cost (-) or benefit (+) per tonne
Charter biofueled coach buses	10	None	$ (5,000)	$ (3,381)	$ (33,814)	$ (38,814)	$ (3,881)	$ (108)
Student shuttles	10	None	$ (5,000)	$ (14,400)	$ (144,000)	$ (149,000)	$ (14,900)	$ (60)
Collaborate w/ ACTR (public shuttle)	10	None	$ (5,000)	$ (1,000)	$ (10,000)	$ (15,000)	$ (1,500)	$ (10)
Moretown methane capture (no revenue)	20	None	$ (65,000)	$ -	$ -	$ (65,000)	$ (3,250)	$ (0.26)
Moretown methane capture (1/2 revenue)	20	3.4	$ (65,000)	$ 18,900	$ 378,000	$ 313,000	$ 15,650	$ 2.50
Print charge - 10% reduction	50	0.0	$ (3,000)	$ 469,530	$ 23,476,500	$ 23,473,500	$ 469,470	$ 24,199
Print charge - 20% reduction	50	0.0	$ (3,000)	$ 417,360	$ 20,868,000	$ 20,865,000	$ 417,300	$ 10,728
Print charge - 30% reduction	50	0.0	$ (3,000)	$ 365,190	$ 18,259,500	$ 18,256,500	$ 365,130	$ 6,263
Online Campus 3000	1	Immediate	$ -	$ 3,125	$ 3,125	$ 3,125	$ 3,125	$ 174
Online Campus 2000	1	Immediate	$ -	$ 9,375	$ 9,375	$ 9,375	$ 9,375	$ 174
Online Campus 1000	1	Immediate	$ -	$ 15,625	$ 15,625	$ 15,625	$ 15,625	$ 172
Online Campus 500	1	Immediate	$ -	$ 18,750	$ 18,750	$ 18,750	$ 18,750	$ 174
Online Campus 0	1	Immediate	$ -	$ 21,875	$ 21,875	$ 21,875	$ 21,875	$ 175
Calculate waste - 1% reduction	10	None	$ (1,910)	$ (2,383)	$ (23,828)	$ (25,738)	$ (2,574)	$ (436)
Calculate waste - 5% reduction	10	None	$ (1,910)	$ (338)	$ (3,379)	$ (5,289)	$ (529)	$ (18)
Calculate waste - 10% reduction	10	0.9	$ (1,910)	$ 2,218	$ 22,181	$ 20,271	$ 2,027	$ 34
Catalog Cancel	1	None	$ -	$ (1,970)	$ (1,970)	$ (1,970)	$ (1,970)	$ (19)
Full Emissions Offset-Future Forests	1	None		$ (576,000)	$ (576,000)	$ (576,000)	$ (576,000)	$ (16)
Full Emissions Offset-American Forests, wildfire	1	None		$ (54,000)	$ (54,000)	$ (54,000)	$ (54,000)	$ (1.50)
Full Emissions Offset-American Forests, normal	1	None		$ (108,000)	$ (108,000)	$ (108,000)	$ (108,000)	$ (3.00)
Full Emissions Offset-Pacific Forest	1	None		$ (108,000)	$ (108,000)	$ (108,000)	$ (108,000)	$ (3.00)
Preservation of Local Forests	1	Immediate	$ -	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 4.00
Reforestation of Local Harvested Forests	1	None	$ -	$ (75,000)	$ (75,000)	$ (75,000)	$ (75,000)	$ (27)
Agricultural sequestration	15	None	$ (304,000)	$ -	$ -	$ (304,000)	$ (20,267)	$ (26)

In the next five chapters, each of these strategies is presented. In the beginning of the sub-section that describes each strategy, the following information is presented in a summary table of this format:

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*

I.5 Notes and References

1. IPCC, 2001: *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881 pp.

2. Climate Change and Vermont. The United States Environmental Protection Agency, EPA 263-F-98-007aa, September 1998. Also found at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ImpactsStateImpactsVT.html

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

4. "A Summary of Energy Consumption and Greenhouse Gas Emissions at Middlebury College,", M. D. Dagan, Middlebury College, Middlebury, VT, December 2002.

5. The Logical Framework

II. Space Heating and Cooling

II.1 Greenhouse Gas Emitting Activities

The primary greenhouse gas emitting activity associated with space heating and cooling is the burning of #6 residual oil in the physical plant. The heat from burning this oil is used to heat steam at a pressure of 200 psi. This steam is then run through a turbine to create electricity and lower the pressure to 20 psi. Running the steam through the turbine (a process called cogeneration) creates electricity, which supplies about twenty percent of the college's yearly electricity need. After being run through the turbine the steam is then piped to all major campus buildings (excluding college houses and other small buildings). This process is only about 65% efficient, meaning that only 65% of the steam actually reaches the dormitories and other buildings. The low efficiency of the current system implies that the savings on any energy efficient heating technologies that we implement will be magnified by an extra 54%.

The burning of # 6 oil (1.7 million gallons in 2000) accounts for 22,000 metric tons of carbon dioxide equivalent emissions (MTCDE) related to space heating and cooling in the year 2000 and approximately 70% of total campus emissions for that year.[1] In several small houses and buildings across campus, propane is used for heating, but the ratio of propane burned to oil burned on campus is minute. Currently, Middlebury uses a 45,000 lb/hour oil boiler, which is capable of fulfilling the majority of the campus's space heating and cooling needs. Occasionally, during intensely cold or hot days, a secondary, smaller oil boiler is used as a supplement. One of our four boilers will reach the end of its lifetime within the next 5 years, necessitating the purchase of a new boiler. The fuel choice for a new boiler will impact the College over the next 50 years—the estimated lifetime of a boiler. It is important that we as a College make informed decisions as to how we heat our buildings over the next half-century. If we choose to continue burning #6 oil as our main source of heat, we will be not only remain dependent on a foreign fuel source, but we will also effectively be ignoring our environmental responsibility.

II.2 Primary Stakeholders

On campus stakeholders would include administrators, such as John McCardell, Ron Liebowitz, and Bob Huth. Facilities Planning staff including Thomas McGinn, Mark Gleason, David Ginevan, Jennifer Bleich, and Doreen Bernier and Campus Sustainability Coordinator Connie Leach Bisson will be part of many changes that could result. Furthermore, individuals in Facilities Management will also play a role, such as Michael Moser, Harold Strassner, Christopher Ayers and Michael Moore. Faculty, staff, and students would also clearly be affected by the changes that are being suggested in this document. Off campus potential stakeholders include Sprague Energy, Biomass Resource Group, Chiptec Wood Energy Systems, Vermont Department of Economic Development, Vermont Department of Forests, Parks and Recreation, Clover State Construction, Vermont Gas, Back East Solar, Vermont Solar, Delta Shower Heads, and the local community.

II.3 Summary of Objectives

1 Reduction of oil use associated with air heating and cooling.

The heating and cooling sector represents the greatest potential for carbon emission reduction in relation to the other areas of focus (electricity, transportation, etc.). At present, space heating and cooling accounts for approximately 70% of all CO_2 emissions at Middlebury College (approximately 27,000 tonnes of CO_2). Furthermore, 70% of the oil burned is directed towards air space heating and cooling during the winter months, while approximately 20% is spent on hot water heating.[2] Technologies and strategies designed to reduce emissions associated with air heating are therefore more critical. However, because water heating and air heating are connected (CO_2 emission source is the same), the only true way to reduce emissions is to switch to a cleaner fuel source, particularly a renewable resource. Thus, switching to biomass will make the largest impact of all strategies for both objectives within the sector, as well as all reduction strategies in this report. Policy based decisions, however, will make some gain in reducing emissions include upgrading windows, lowering the thermostat to 68 degrees, requiring new buildings to have passive solar design, and an education campaign.

2 Reduction of oil use associated with water heating

Middlebury College produces 3,800 tons CO_2 per year for domestic hot water use, as a by-product of oil burning. As mentioned, 20% of our total steam goes toward domestic hot water heating. We can reduce the magnitude of this need through solar water heating and other solar appliances, which will both reduce CO_2 emissions and save money. Installing low-flow water heads will also make a small contribution to lowering the amount of water Middlebury needs to heat per day, consequently reducing emissions associated with water heating.

II.3.1 Reduction of oil use associated with air heating and cooling.

Summary of Strategies

- ***a. Thermostat adjustment***
- ***b. Biomass supplement***
- ***c. Passive Solar Design Policy***
- ***d. Education***
- ***e. Window replacement and upgrade***

II.3.1.a – Thermostat adjustment

Summary data

Index rank	Payback time (years)	Annual tonnes CDE	Total (cost) or benefit per tonne
12	Immediate	459	$ 70

We have found that the easiest way to begin reducing Middlebury's CO_2 emissions, while still effecting substantial GHG reductions, is to turn down the thermostats of campus buildings. Even a small change in temperature can greatly decrease the amount of #6 oil burned to heat the buildings. The Minnesota Department of Energy says that for each degree that one turns down the thermostat (in a home), the home saves one percent of heating costs. At Middlebury, we figure a similar percentage applies—that a two-degree decrease in the temperature of buildings heated by the main plant would lead to two percent yearly savings in heating costs. If this were the case, the school would save approximately $30,000-$35,000 per year. Lowering thermostats in Bicentennial Hall, for example, is not an involved process—the building is equipped with over 20,000 sensor points and all temperatures are coordinated electronically. Currently, daytime temperatures at Middlebury are set at 70°F, and nighttime temperatures are set at 65°F. We recommend leaving the nighttime temperatures at 65°, while lowering daytime temperatures to 68°. Summertime air-conditioning temperatures should be raised from 74° F to 76° F.

Timeline

Such a simple initiative as turning down the campus thermostats would require no waiting period or research period. A small period of time, maybe one to two weeks, could be used to increase student, faculty and staff awareness about the reason for decreasing academic building temperature and the positive environmental consequences of doing so. The college community could be advised to wear an extra layer of clothing beginning on the day of lower temperatures. However, if the college decides to go ahead with lowering thermostats, the timeline for this strategy is effectively immediate.

We envision a revising of the heating and air-conditioning policy on campus as a permanent strategy. Unless the school received numerous complaints of discomfort associated with lack of heat or discomfort associated with lack of adequate air-conditioning, the policy should remain unchanged. Furthermore, the college could provide space heaters if the complaints were relatively sparse. SUNY Buffalo has lowered their temperature to 68 degrees, and provides space heaters when requested.

Magnitude of Potential GHG Reduction

If we turned campus thermostats down to 68°F, we would burn 35,000-45,000 fewer gallons of oil over the course of one year. This would reduce Middlebury's CO2 emissions by 400-500 tonnes per year—an approximate 2-2.5% reduction of current emissions associated with heating and cooling.

Benefits and Costs

Fixed Cost

The Fixed Cost for lowering the thermostats are negligible. All this strategy requires is one person to electronically or manually adjust temperature settings from the heating plant in the service building or in individual buildings. The primary Fixed Cost would be a campus education campaign about the merits of reducing CO_2 emissions by lowering building temperatures. The coordinators of this campaign, members of the faculty, would surely work longer hours and require a pay bonus. There would also inevitably be copying and printing fees for posters and other public education tools. However, we do not anticipate the total Fixed Cost to be very high.

Variable Cost or Benefit

There would be no operating costs associated with this strategy. Once the temperatures are set, the temperatures would remain at that level and would not require constant attention. One negative cost would be the savings Middlebury would accrue from using less oil—as mentioned earlier, approximately $30,000-$35,000 per year of 68°F temperatures.

Other Costs and Benefits

Social. A "grumbling factor" could arise from the campus population as people cope with lower temperatures, causing mild dissatisfaction among few people. However, we are confident that once the complainers understand the reason for temperature reduction, and once they learn to dress appropriately, the "grumbling factor" will decrease. As a case study example, during the month of January, Room 104 Bicentennial Hall was reduced to 65°F where our class was being held. Although a little uncomfortable at first, we eventually began avoid wearing clothing appropriate to the temperature. In addition, the classroom remained at this temperature for the following class. There were no complaints from these students (they were told of the adjustment in advance, and presumably dressed accordingly).

Public Relations. Consciously lowering our thermostats would be educationally valuable for Middlebury visitors, students, alumni, staff, and faculty. The reduction of temperatures could be a P.R. benefit, as it would display Middlebury's environmental consciousness and activism.

Cross-cutting areas and synergies. By burning less oil on campus we would inevitably affect our cogenerative electricity production. It is unknown at this point how much of an effect lowering the thermostats would have on cogeneration.

Possible Financing Mechanisms

We do not anticipate any funding necessary for this strategy, either at the present moment or at any point in the future. In older buildings with less advanced controls, the thermostats may have to be adjusted manually, but this can be done with minimal cost. Upgrades are not necessary in these buildings.

Stakeholders

On campus

All faculty, students, and staff of Middlebury College—especially staff such as Tim Wickland, building manager of Bicentennial Hall, Michael Moser, central heating plant manager, and George McPhail, staff engineer of the service building, and Campus Sustainability Coordinator Connie Leach Bisson.

Off campus
Sprague Energy (Rensselaer, NY), our current oil provider

Examples from elsewhere

Other Colleges and Universities

Bowdoin College
SUNY Buffalo
Tufts University
University of Vermont
Williams College

The institutions of higher learning mentioned above all have their own policies on heating and air-conditioning temperatures. Most schools heat their dormitories to the same temperature as academic buildings, but allow for individual room adjustment. Williams, for example, sets its thermostats at 69° F but allows individual rooms to be heated to as high as 74° F. With regards to thermostat settings during periods when a building is not being used, the schools also have different policies. University of Buffalo has one of the best policies in this regard, where during off-hours, weekends and holidays, the temperature is reduced to 55° F in the winter and central air-conditioning is shut off during the summer.

We compared Middlebury's temperatures to those of these schools, and found that, in general, Middlebury maintains its buildings at a warmer temperature than most other schools in the winter, and cooler than others during air-conditioning months (Figures II.1 and II.2). If students, faculty and staff at schools like ours live at 68° F, then why shouldn't we Vermonters be able to do the same thing?

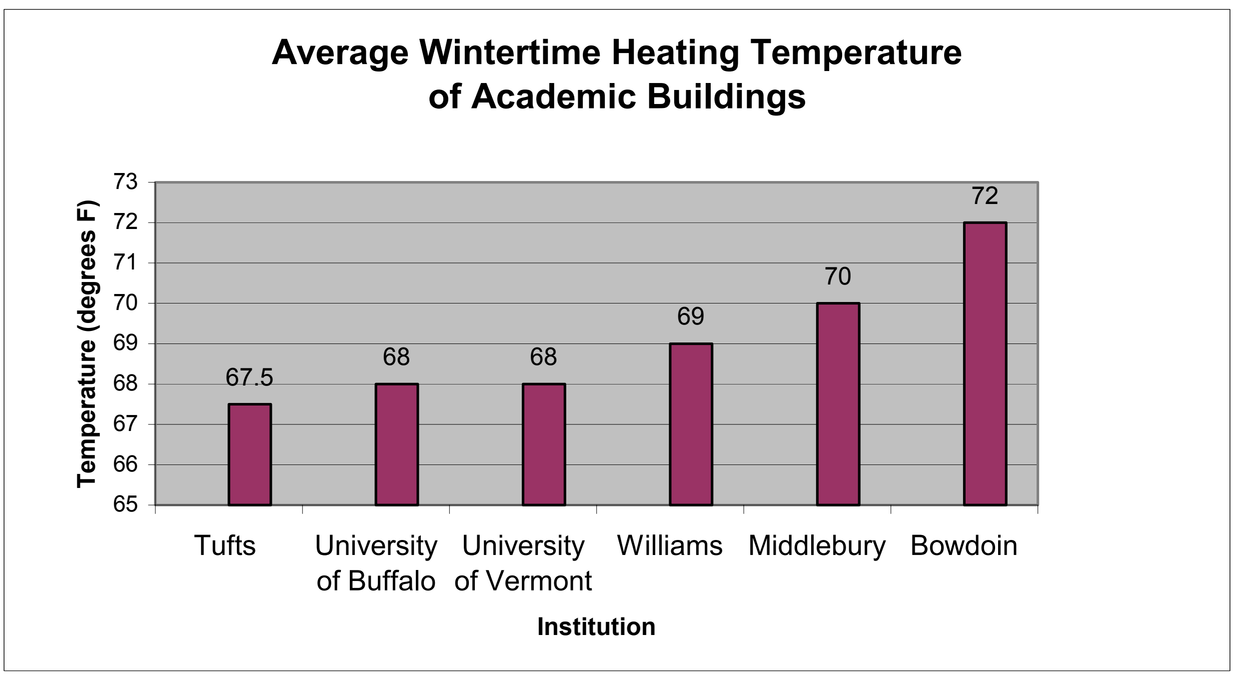


Figure II.1. Average wintertime heating temperature setpoints of academic buildings in respective New England area schools. A higher temperature signifies greater fuel consumption, and, hence, greater CO_2 emissions associated with heating.

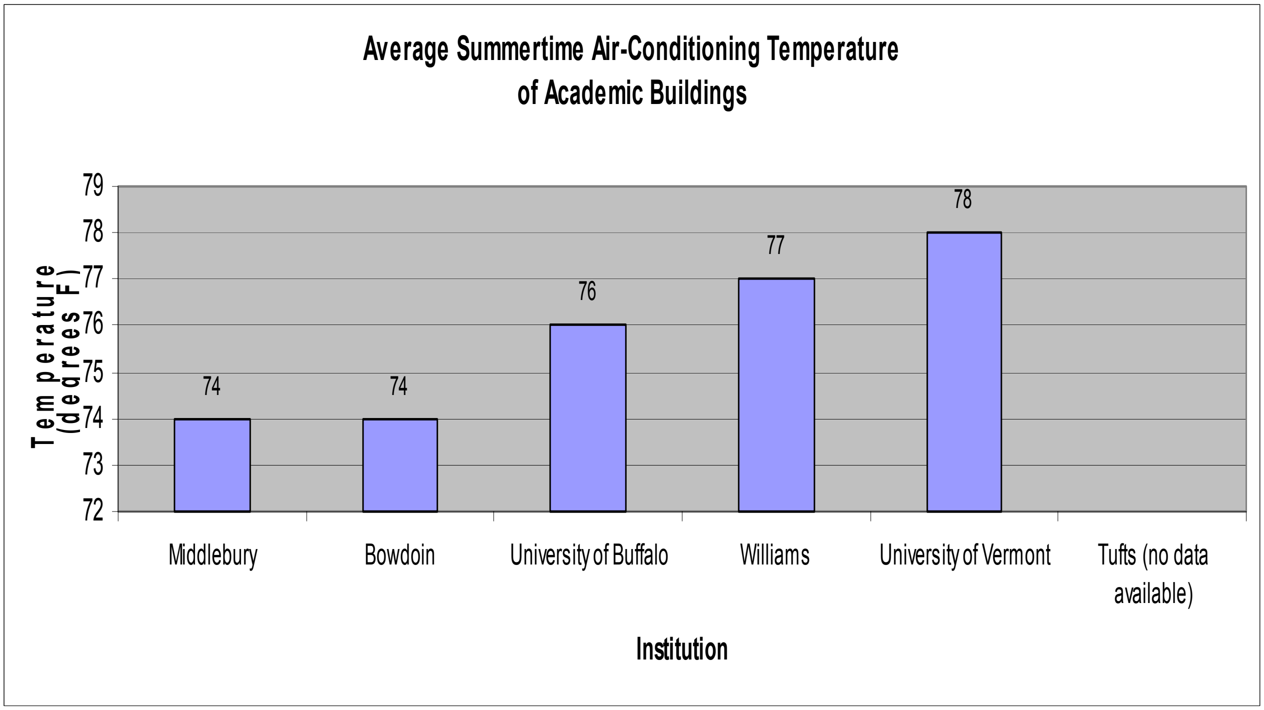


Figure II.2. Average summer air-conditioning temperatures in respective New England area schools. A lower temperature signifies greater fuel consumption by the air-conditioning system, and hence greater CO_2 emissions associated with space cooling.

Getting Started

As previously stated, lowering the temperatures of academic buildings represents a simple and effective way to reduce our ecological footprint through reducing carbon emissions. The process is not difficult, but a discussion should ensue between Facilities Management (spokesperson Michael Moser) and College administration. Students, faculty and staff would benefit from and appreciate an awareness campaign that spells out what's happening to building temperatures and why. After that, Middlebury would immediately begin to see the positive economic and environmental impact of the reduced campus demand for heat and air-conditioning.

II.3.1.b – Biomass switch/supplement: scenarios 1 and 2

Summary data (full switch to biomass)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
9	2.8	22,000	$ 27

Summary data (partial switch to biomass)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
11	5.7	11,000	$ 25

The construction and operation of the McNeil Power Plant in Burlington, Vermont has shown Burlington Electric Department's commitment to using biomass as a renewable energy resource. There are zero net carbon emissions associated with biomass burning, because although CO_2 is released into the atmosphere during the burning process, it is quickly sequestered back when trees are replanted in the same place- therefore being rotated within twenty years in the earth-atmospheric cycle. In contrast, when oil is extracted, it is taken from the atmosphere-geologic cycle, and therefore the carbon released when oil is burned will not be sequestered back into the ground for hundreds of thousands of years. Thus, by relying less on oil, which has associated high emissions, and relying more on biomass, with zero net emissions, the college will significantly reduce the amount of its emissions.

Through a process called gasification[3], wood chips are burned to produce the necessary steam to heat and cool buildings, as well as turn the turbine to produce electricity identical to the process used when oil is burned and electricity is co-produced (cogeneration). Several Vermont government buildings have switched to biomass, and the State assisted the switch in 24 public schools throughout the Vermont. The wood chips to fuel biomass boilers often come from low quality trees and harvest residues, as well as wood waste from sawmills and lumber companies, consequently decreasing the amount of wood waste going into landfills. Aside from lowering emissions and saving money, if Middlebury chose to switch to biomass as its main energy source, the College would likely be recognized throughout the state as a model of the benefits associated with this technology. Furthermore, it is certain that as the climate change problem becomes imminent to national decision makers, much like the ozone layer crisis forced policy makers to make particular choices, there will be increased pressure to switch to cleaner sources of fuel in the US and throughout the developed world where energy demands are high.

Within this strategy, we outline two scenarios. One entails switching completely from #6 oil to biomass, while the second strategy involves using biomass as a supplement. It should be noted that in 5 years the College plans to buy a 50,000 lb boiler, which will be the main provider of air heating and cooling for the entire campus for the next 50 years.

Strategy 1: Instead of purchasing a new oil boiler, the College could choose instead to buy two 30,000 lb biomass boilers. These boilers would supply the College with all of its energy needs. To store the chips necessary to fuel these boilers, the College would have to build a storage facility of approximately 30,000-40,000 cubic feet, as well as make the current service building accessible to large trucks that would deliver approximately 26 tons of green chips/week. Currently, seven oil tankers deliver to Middlebury per week. The storage facility could be built adjacent to the service building, where they already intend to prohibit parking in the near future. Some storage models are in part underground, which minimize undesirable aesthetics of the facility. Another option, which would be far more massive, could be to move the entire service building to a new location, such as the area next to the graveyard, across from the athletic center. It has been noted that the current location of the service building is not ideal due to the smoke stack in the heart of campus, but also in part to the poor aesthetics of the building design. This move would clearly involve much more effort and require re-venting the main duct to the new location. However, if the College chose to switch completely to biomass, the payback would be approximately 15 years (assuming the price of moving the facility would be approximately 7 million dollars).

Strategy 2: Instead of purchasing one new boiler, the college could purchase a 30,000 lb biomass boiler, in addition to a 30,000 lb oil boiler, using the former as the primary source of steam for heating and cooling and supplementing this source with oil only during months of extreme hot or cold. In this scenario, fewer trucks/week would be needed to provide the necessary chips for burning and oil delivery, and the storage facility necessary to house the chips would also be smaller (20,000 cubic feet). The length of each side of the two story building would therefore be approximately 35 feet, which can feasibly fit in the nearby parking lot space. The building could even be designed to look like a barn or a silo to mimic Vermont architecture and reduce possible negative aesthetic effects of the building. The environmental sustainability of the project would also be less questionable, because half the amount of wood would be needed.

Timeline

Middlebury College is planning to replace the current 45,000 lb boiler with a 50,000 lb boiler in 5 years. Thus, it is within this time frame that the College should seriously consider changing fuel sources. Biomass is the fourth largest source of energy in the United States preceded by coal, oil and gas. The average lifespan of a biomass boiler ranges from 20-75 years depending on the model, how well the boiler is maintained, and the type of chips burned. In the following analysis, we assumed the lifetime of the boiler to be 50 years.

Strategy 1: Middlebury should commit to this source of energy for at least this 50 year lifespan. Unless new technology is developed to exceed the environmental and cost effectiveness of this source, the College can rely on this strategy indefinitely provided wood suppliers continue to harvest sustainably.

Strategy 2: Similar to strategy 1, the biomass boiler could be relied upon for at least 50 years before replacement, as would an oil boiler.

Magnitude of Potential GHG Reduction

Strategy 1: Switching to biomass for all of Middlebury's space heating and cooling needs based on 2000 data would lead to a 60% reduction in CO_2, (22,000 tons of CO_2 equivalents/ year).

Strategy 2: If Middlebury chose to rely solely on biomass for half of its energy, the total CO_2 reduction would be a 30% reduction (11,000 tons of CO_2/ year). This estimate is based on the notion that the 30,000 lb biomass boiler would be operating at full and that the current oil boiler or its 30,000 lb replacement would be operating at half.

These numbers were attained using 2000 data on number of gallons of #6 oil Middlebury used assuming there was no net emissions associated with biomass burning (0.013 tonnes CO_2/gallon of #6 oil).

Benefits and Costs

Fixed Cost

Strategy 1: The startup costs of this project would be high (3.8 million dollars). The building of a storage facility to house the chips would cost approximately $45,000 (assumes a facility that is two-stories high, 40,000 cubic feet, costing $18/square feet, housing three days supply of chips). The cost of the storage and delivery system would cost approximately $750,000. In addition, the installation and purchase of two new 30,000 lb biomass boilers would range between 2 and 3 million dollars. In comparison, a new 50,000 lb oil boiler would cost approximately 1.5 million dollars.

Strategy 2: The startup costs for this option would also be high (2.52 million dollars). A storage facility (20,000 cubic feet) would cost approximately $23,000, and the storage and delivery equipment for this facility would cost about $500,000 (same assumptions as strategy 1). The installation and purchase of one 30,000 lb biomass boiler would cost approximately 2 million dollars. It would probably not be necessary to purchase a supplemental oil boiler. Recently, the College purchased a 45,000 lb boiler, which must be utilized so the College can maximize its investment on the purchase. Thus, the biomass boiler could be the primary source of energy supply, while the recently purchased boiler could act as a supplement during extreme hot and cold days.

These high-end estimates were provided by Brad Noviski at Chiptec Wood Energy Systems (brad@chiptec.together.net), Burlington, VT.

Variable Cost or Benefit and Benefits

According to Chiptec Wood Energy Systems, the operating costs would be approximately the same as current cost for oil. ($250,000/year). However, one must anticipate some increase in costs associated with ash disposal and chip handling. The price of wood chips would be on the high-end approximately $25/ton, the current price of oil is $0.69/gallon, however in the year 2000 the price was $0.80/gallon.

Strategy 1: The price difference in cost of fuel based on 2000 oil prices would result in an annual savings of $631,300. The payback time would be approximately 5 years, and would result in a total savings over a 50-year period of 31.6 million dollars. Other potential costs and benefits are related to the way Middlebury would choose to dispose of the ash. Brad Noviski at Chiptec estimates that one 30,000 lb boiler would result in 150-200 lbs of ash per day using green chips or approximately 0.7 tons/week. If Middlebury chose to landfill the ash, it would cost an additional $11,000/year, assuming the cost/ton for trucking and disposal was equivalent to $150/ton. Composting the ash would be less expensive, approximately $3,600 /year ($50/ton), although the College would need to expand the current composting site, because it is currently operating at maximum.[4] However, if the College chose to sell the ash as fertilizer to local farmers, the net benefit would be $1800/year ($24/ton).[5] Another option for ash disposal is to spread it along icy walkways during winter months. The operating cost of this option would likely be null, in fact, the College would no longer need to purchase sand and therefore this could be a possible financial benefit.

Strategy 2: The annual savings of supplementing oil burning with biomass would result in an estimated annual savings of $309,300 based on 2000 figures. The payback time would be approximately 7 years, and would result in a total savings over 50 years of 15.4 million dollars. To landfill the ash, it would cost an additional $5,500/year, assuming the cost/ton was equivalent to $150/ton. Composting the ash would be less expensive, approximately $1,800 /year ($50/ton), although the college would need to expand the current composting site because it is at present operating at maximum. However, if the College chose to sell the ash as fertilizer to local farmers, the net benefit would be $900/year ($24/ton).

In addition: The cost of oil has traditionally been unstable in comparison to wood. Figure II.3 illustrates this difference. Using biomass for fuel will stabilize energy costs at a reasonable level, often lower than current oil costs. In addition, Middlebury currently plans for the construction of several new buildings associated with the implementation of the Commons system, which by default will increase the demand on heating and cooling at the College. As space heating and cooling demands rise, the fluctuating oil prices will tend to have a greater impact on the energy costs of the college.

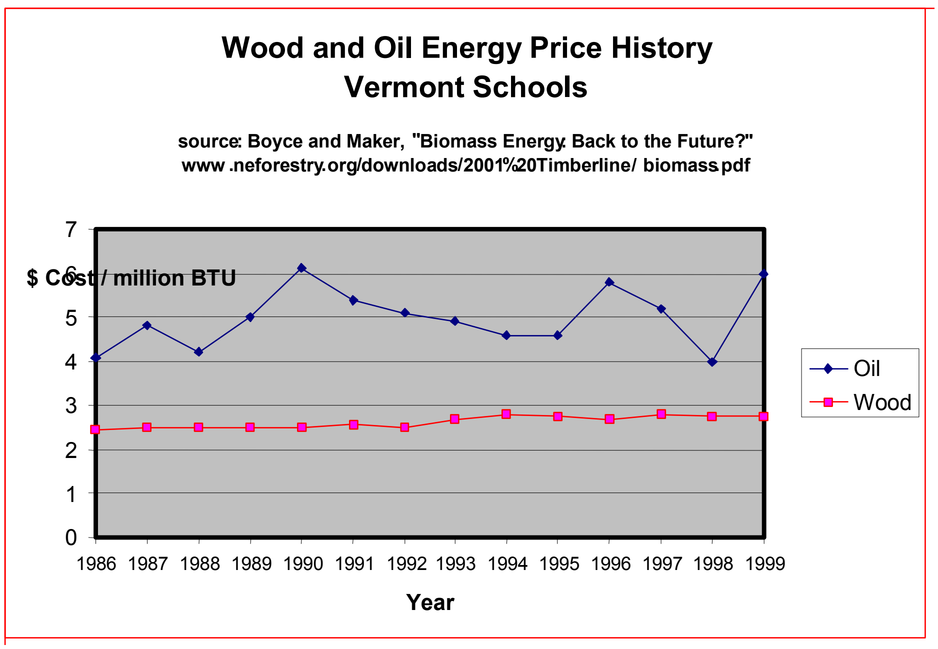


Figure II.3. Biomass energy cost stability.

Other Costs and Benefits

Environmental. Forest and mill residues release methane into the atmosphere, which has a greater impact on climate change than CO_2 emissions. According to the Vermont Agency of Natural Resources, mills are able to market 46% of wood wastes in Vermont for biomass energy. Creating a market for low-quality wood would provide incentive for local forest landowners to thin and utilize other forest stand management practices that normally would not be affordable. Switching to biomass would also contribute to the creation of early successional habitats in a cost-effective manner. Inevitably, there are also potential negative effects on the ecosystems of Vermont forests. However, if forests are harvested sustainably, this impact would be minimal. The current estimate of the necessary wood chips needed is 26 trailer trucks per week for a full biomass conversion, and 13 tractor trailer trucks of chips for a half biomass supplement. This amount is equivalent to 3-4 tons of chips/hour for the former strategy, and 1-2 tons/hour for the latter option. Currently, the McNeil Power Plant uses 76 tons of chips/hour and has received much acclaim for attaining chips from harvesters who meet strict environmental standards, therefore suggesting that Middlebury's impact should be minimal by comparison. The Vermont Department of Forests, Parks and Recreation is committed to ensuring the sustainability of biomass suppliers as overviewed in their strategic plan outlining objectives and goals between 1999-2004. Paul Frederick and Bob DeGeus at the Vermont Department of Forests, Parks and Recreation are two important contacts to discuss the sustainability of the project.[6] David Brynn, Addison County Forester and Executive Director of Vermont Family Forests would also serve as an important resource.

Social. This project would have an educational value for Middlebury visitors, students, alumni, staff, and faculty. However, it should be expected that the initial reaction by some individuals would question Middlebury's ability to use a wood chip supply that is harvested in a sustainable manner. It would therefore be Middlebury's responsibility to first develop a definition of forest sustainability, and then only purchase chips from suppliers who harvest wood accordingly.

Public Relations. The use of local companies to supply and deliver wood chips, will increase the number of local jobs. The plant will be far ahead of other colleges and universities in making a true commitment to renewable types of energy. Vermont has led the nation in biomass production through the installation of the McNeil plant in Burlington. By choosing biomass, Middlebury will be recognized as an institution committed to sustainability and shifting the region to greater dependency on local renewable energy sources.

Cross-cutting areas and synergies. If the ash were composted, the solid waste sector would be affected. The cost of increasing the composting site to accommodate the load increase was not included in the calculation. The campus fleet would also likely increase its travel, due to biomass burning, because of the additional transport needed for ash disposal. The electricity that the storage delivery system would require may result in a minimal increase in CO_2 emissions.

Possible Financing Mechanisms

Vermont Energy Investment helped sponsor the installation of a biomass boiler in Barre, VT in Green Acres, a 50 family apartment complex (granted $105,000). It is possible that they might be a financial supporter of this project. Contact: dhill@veic.com (802)658-6060.

Biomass Energy Resource Center is unclear at present on its ability to provide any funding for this project, although they are extremely interested in working with Middlebury College at every stage of the implementation process. Their ability to provide financial assistance is pending on receiving more federal funds for which they have applied and waiting for a response. Contact: Timothy Maker, Director of Biomass Energy Resource Center, (802)223-7770, tmaker@biomasscenter.org.

Efficiency Vermont currently works with Middlebury as an energy consultant. They occasionally can provide funds for energy savings projects, and could be a potential resource.

Stakeholders

On campus

Staff: Facility Panning, Campus Sustainability Coordinator, boiler operators/engineers, general administrative staff, upper administration, compost facility manager

Faculty and Students

Off campus

Sprague Energy (Rensselaer, NY): current oil provider
Biomass Energy Resource Center
Chiptec Biomass Company
John Hurley & JH Lumber
A. Johnson Lumber
Cersosimo Lumber Company
Other lumber mills
Storage facility contractor
Individuals in the community
Local Community
Efficiency Vermont
Vermont Energy Investors
Vermont Department of Economic Development: George Robson[7]
Vermont Department of Forests, Parks, and Recreation: Bob DeGeus and Paul Frederick
Vermont Family Forests

Examples from elsewhere

Other Colleges and Universities

Mount Wachusett Community College. Mount Wachusett Community College is located in Gardner, Massachusetts and has a 405,000 square foot campus. The College, in collaboration with the Forests & Wood Products Institute, has changed from an all-electric fuel source to a hydronic wood chip fuel that will supply the campus with space heating and cooling, as well as hot water. The College estimates that its annual savings will be approximately $280, 000. The initial cost of the project is estimated at 3.5 million dollars, which will be paid back in approximately 9 years. The project received $1,000,000 in federal support by the US Department of Energy under the FY01 Energy and Water Development Appropriation Bill. The college will serve as an example and an educational tool for all nearby institutions within the Commonwealth, as well as throughout New England.[8]

Future potential: University of Iowa. The University of Iowa has been collaborating with Quaker Oats on a project that would entail using oats as part of the University of Iowa's fuel source. The University has a massive biomass research initiative in their environmental sustainability division.[9]

Other Institutions

Vermont State Police Academy
Murray Farms
McNeil Power Station
Chiptec has installed 125 boilers in the Vermont area in the past 17 years including public schools and government buildings.

Getting Started

We recommend having a luncheon panel with individuals from several key stakeholders to discuss the feasibility of the project. Representatives from Biomass Resource Center, Paul Frederick and Bob DeGeus of the Vermont Department of Forests, Parks and Recreation, George Robson of the Vermont Department of Economic Development, and a representative from Vermont Energy Investment Corporation (perhaps David Hill). David Brynn, as an expert of sustainable forestry in this area, might also be able to provide valuable insight into the sustainability of the project. Prior to this luncheon, the consultant from the Biomass Resource Center, preferably Tim Maker, should review Middlebury's current system and anticipated needs and be knowledgeable about the benefits and costs of implementing this strategy.

II.3.1.c – Passive Solar Design Policy

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
15	None	-	$ -

Middlebury College seems to be constantly under construction and has created a new dormitory, a new dining hall, and a large academic building in the last five years. As a result of this construction, there have been large increases in the heating and cooling needs for the school (Figure II.4). This in turn has led to higher energy costs for the school that could have been lessened had the school incorporated passive solar design. The College is in the process of building a new library, dining hall, and dormitory. However, in each of these cases, the College and its hired architects have largely ignored passive solar heating. Solar passive heating consists of an architect incorporating simple architectural designs into the creation of any new building. This could be done on campus without impacting the aesthetics of the building and having minimal or even no extra costs associated with construction. By incorporating passive solar designs in the construction of new buildings the school would save on energy needs for the lifetime of that building.

When a building is designed using passive solar heating, many simple measures are used in the design. The most important and most simple measure used in passive solar design is orienting the building so that the longest walls run from east to west. This design enables the maximum amount of sunlight to hit the building, which provides natural heat in the form of solar radiation. The next step that is directly related to the first is having the majority of the windows facing south. Southern exposure allows the sun's radiation to provide heating. These windows would be the more high-tech models that allow the sun's heat in while insulating against the cold. To improve the heating associated with solar heat gain through windows, the building could use concrete, stone slabs, or masonry partitions for the walls and flooring. These materials hold heat and slowly release it at night when heating needs are the highest. All of these methods involve the direct gain of solar heat ("Passive Solar Heating"[10]). By using these simple methods in the construction of a building, heating costs will be much less for the building and there will be no noticeable visual differences.

In addition, isolated gain of solar heat can be used to provide heating for a building. This can be done through the incorporation of a system that is isolated from the primary living space such as a sunroom or solar greenhouse. These rooms maximize the amount of solar heat gained by having large windows that face south. These rooms are designed to gain heat and then subsequently ventilate it throughout the building using convective loops ("Passive Solar Heating"). While these systems add another dimension to the construction of the building, they provide more natural heating by harnessing the sun's power.

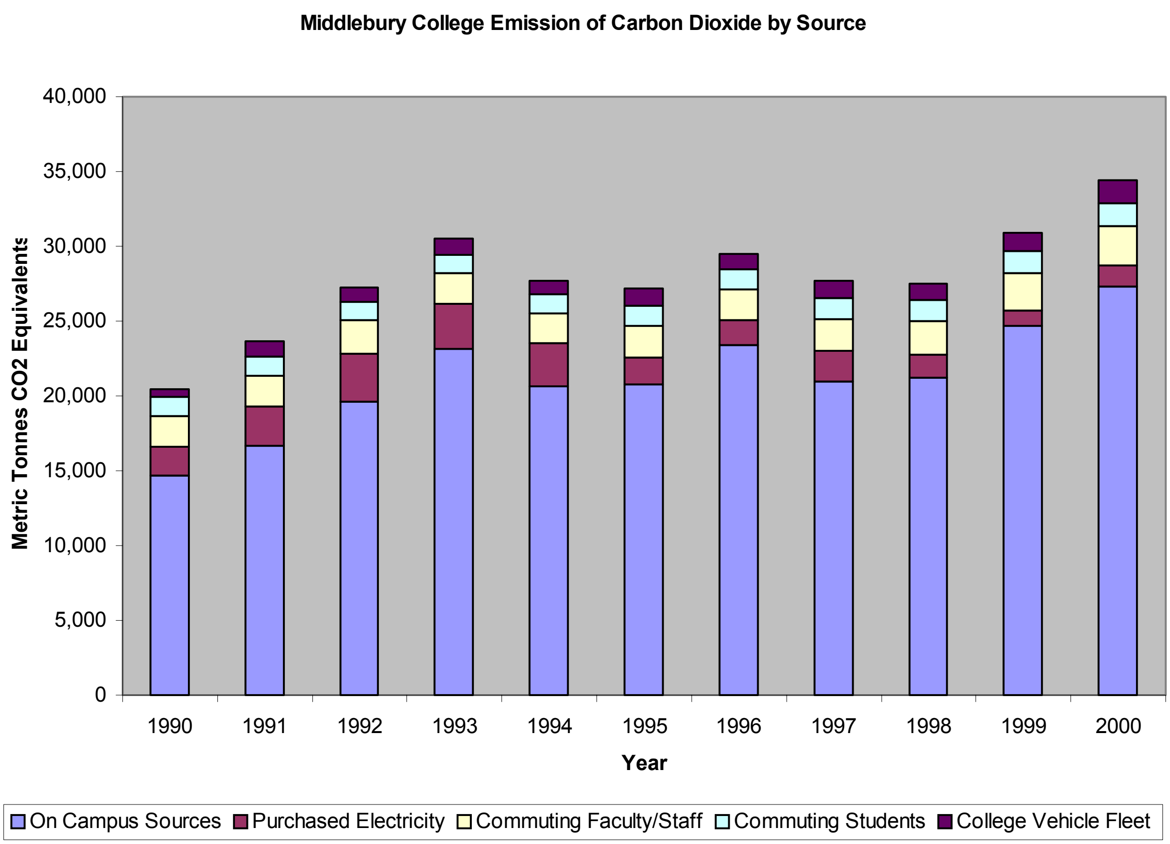


Figure II.4.: Increased heating and cooling needs after the 1993 construction and 2000 construction of Bicentennial Hall.

As for passive solar cooling for a building, this can be accomplished using a variety of simple strategies and some more complex strategies. For instance, shading and overhangs will reduce summer heat gained through a window while not excluding winter sunlight. Other more technical strategies used for passive solar cooling have more of a visual presence for the building. These strategies include adding wing walls and thermal chimneys. By installing casement or other operable windows for passive solar gain and adding vertical panels (wing walls) perpendicular to the wall on the windward side the natural breeze is enhanced inside of the room. Thermal chimneys on the other hand are built like smoke chimneys but vent hot air out of the building through the roof ("Passive Solar Heating").

The incorporation of some or all of these strategies into the construction of a new building will help save the College money in a short period of time while taking advantage of the Earth's largest natural resource: the sun.

Timeline

Mandating the use of passive solar design could be incorporated immediately into College policy. This would mean that passive solar heating would not become a reality until the design and construction of the next new building.

Magnitude of Potential GHG Reduction

The magnitude of potential CO_2 reductions would vary from building to building depending on its size, location and which strategies the school decided to incorporate into the construction. Obviously, if a building such as Bicentennial Hall used passive solar heating to reduce energy cost, the reduction of CO_2 needed to light and heat the building would have been much greater than if LaForce Hall had been constructed with passive solar techniques, due to the simple difference in size. Also, the impact of passive solar heating could be compromised if the sunlight reaching a new building was obstructed due to the presence of an already existing building. Finally, there are many different measures the school could incorporate into architectural design to utilize the benefits of passive solar "technology." The more aspects of this design the school embraces, the greater the increase in Middlebury's overall emissions will be.

Benefits and Costs

Fixed Cost

In a case study performed by the National Renewable Energy Laboratory in the 1980's, 19 new and retrofit passive solar commercial buildings were examined. Construction costs for these building ranged from \$46-\$85/ft^2 and on average were the same as the costs associated with the construction of a conventional building. When costs for passive solar buildings were more expensive, the increase never exceeded a 10% increase than its conventional counterpart ("Passive Solar Design"[11]).

Variable Cost or Benefit

Operating costs are less than those associated with conventional heating, cooling, and lighting. Again, in the study conducted by the National Renewable Energy Laboratory, the 19 buildings that incorporated passive solar heating had energy costs that were on average 51% less than the energy costs if the building had been constructed using conventional methods ("Passive Solar Design").

Other Costs and Benefits

Social. Passive solar heating has been shown to increase worker productivity in the work place ("Passive Solar Design"). Perhaps, the brighter atmosphere will have the same effect on Middlebury students, faculty and staff.

Public Relations. This design strategy would show the local community and other schools around the country the benefits of using passive solar heating and would also show that Middlebury College truly is an environmentally conscious campus.

Cross-cutting areas and synergies. Passive Solar Design can lead to lower lighting needs and thus save on electricity use in the building ("Passive Solar Design").

Possible Financing Mechanisms

Since construction costs for passive solar buildings can be the same as conventional buildings, funding would be through the normal channels. Sometimes passive solar design is slightly more expensive than conventional design. Efficiency Vermont rebates money for projects designed to save electricity. In 2001, they worked with 77 commercial and industrial institutions in Vermont in new constructions. Though not for passive solar features, Middlebury has received financial incentives for constructing energy efficient buildings. In addition to the on-going energy savings during the life of the building, Efficiency Vermont's financial incentives for passive solar design may be enough to cover any additional costs associated with the passive solar design and may even lower construction costs to a level below that of conventional construction.

Stakeholders

On campus

Students
Staff
Faculty
Facilities Planning (e.g. Thomas McGinn, David Ginevan, Mark Gleason)
Facilities Management
Campus A/C committee
Program Committee of future construction project

Off campus

The architect hired in the construction of a new building on campus
The construction company hired to build a new building on campus
Vermont Yankee Nuclear Power
Sprague Energy
Efficiency Vermont

Examples from elsewhere

Other Colleges and Universities

Oberlin College's Lewis Center for the Environment-The center has large windows facing the south. These windows allow heat to go into a sunroom as well a greenhouse. The flooring of the sunroom consists of stone slabs and the walls are brick (Figures II.5 and II.6).

The Yapeyu School in La Jaula, Argentina

Sede-Boqer Campus in Negev highlands, Israel

Figure II.5. South facing windows at Oberlin College's Lewis Center for Environmental Studies.

Figure II.6. Sunroom at Oberlin College's Lewis Center for Environmental Studies.

Other Institutions

17,000 commercial buildings across the United States incorporate passive solar design ("Passive Solar Design").

Getting Started

In order to incorporate passive solar design, Middlebury College would need to go through the normal channels it uses to construct new buildings. If the architect was not familiar with passive solar design, then they could do some simple research on the Department of Energy's website (http://www.eren.doe.gov/RE/solar_passive.html) and hire a consultant to assist with this component of the design. However, most architects are familiar with this technology. The most important part of passive solar design is that it is incorporated at the very beginning of a project.

II.3.1.d – Education campaign

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
23	Immediate	23	$ 52

One of the easiest and most cost effective ways to reduce energy consumption is through education. Education is fundamental in converting ignorance (of the environmental impacts associated with personal space heating) to knowledge. By teaching people that they can help reduce CO_2 emissions associated with heating, they will become more cognizant of their ecological foot print and may in turn start promoting more environmentally friendly technology. We feel that one of the better ways to educate the Middlebury community is by enticing them into competition with one another and rewarding those who perform the best.

Our plan is to hold a competition on Middlebury campus entitled "How Low Can You Go?" Ideally this competition would be between different dormitories on campus. Unfortunately there are currently no meters on campus that measure the steam flow to an individual dormitory, however some meters are being installed. Nevertheless, we plan on starting the competition in Bicentennial Hall between the different academic departments that are based in the building. From the energy management system computer operated by Facilities Management, the temperature in the different offices can be controlled. Our plan is to first educate faculty on how they can lower heating costs associated with their offices. Since the space is small there are only a few steps that can be taken. First, they can comfortably work in their office at lower temperatures if they were to wear a fleece instead of only a long sleeved shirt. Next, they can inform Facilities Management of their normal office hours so the temperature in their offices can be lowered when not in use. Also, faculty could inform Facilities Management if they will not be in town for a few days, so their office is not heated to such a high degree when they are gone. The competition will start October 1 and will last until the last day of the fall semester. At this time, the average temperature of the offices for each department will be calculated and the department with the lowest temperature will be rewarded with free CO2 Neutral Middlebury College fleeces.

In the future, when meters are installed to measure the flow of steam to each dormitory, the competition will be campus wide. In a dormitory, there are even more strategies that can be implemented in order to reduce the amount of steam needed to heat the building and its water. Students could take shorter showers and not leave the faucet running when shaving or washing their faces. By minimizing these simple daily activities the steam needed per dormitory will decrease. Also, by closing window blinds at night not only will the sun not wake them up, but also there is less heat loss between the cold outside and the warm room due to the added insulation ("How to Save Energy"[12]). Another strategy that could be used is as simple as not opening their windows during the cold winter months. The winning dormitory will be the one that had the greatest percentage of reduction in steam as compared to the previous winter term. Then the winning dormitory will be treated to pizza sticks and Ben & Jerry's ice cream.

The whole point of this exercise is to show the Middlebury College community that they can still live comfortably while reducing CO_2 emissions associated with heating the campus. While the college may not save a significant amount of money while hosting this competition, the competition will hopefully promote wiser use of heating by the college community.

Timeline

The competition between faculty departments in Bicentennial Hall could be held in the fall term of 2003.

The competition within the student body will have to wait for a few years because the meters that measure steam flow for a particular dormitory have not yet been installed.

Magnitude of Potential GHG Reduction

Only minimal reduction of CO_2 will be associated with the faculty competition since the competition takes place on such a small scale.

The student body competition has the potential of reducing a noticeable amount of CO_2 emissions, but these emissions probably will not be a significant part of the total emissions associated with space and water heating.

Benefits and Costs

Fixed Cost

The prize money in both competitions will be approximately $400, which is enough to supply a fleece for each faculty member in the winning department and ample money to provide a dormitory with pizza sticks and Ben & Jerry's.

Variable Cost or Benefit

For the faculty competition either the energy management system manager will have to be extremely generous and offer their time to set temperatures for each office or a volunteer running the competition could take over that responsibility. As for the student competition, volunteers running the competition will have to do the calculations on the reduction of steam used.

Other Costs and Benefits

Environmental. The benefit of this competition is less CO_2 emissions associated with heating and a lifetime of improved individual responsibility.

Social. If people want to be involved in the competition they will need to alter some of their daily activities. The competition will lead to increased awareness regarding the heating of Middlebury College.

Public Relations. This competition could be used as a model for other colleges and institutions to implement in their operations.

Cross-cutting areas and synergies. This education may lead to increased environmental awareness across campus in other areas such as electricity, transportation, and solid waste.

Possible Financing Mechanisms

Since the funding for this educational project is minimal, Middlebury College could easily cover the costs. In addition, the possibility exists that Ben & Jerry's would be willing to donate ice cream as part of the prize for the student competition.

Stakeholders

On campus

Students
Faculty
Campus Sustainability Coordinator

Off campus

Sprague Energy
Ben & Jerry's
Neil & Otto's

Examples from elsewhere

Other Colleges and Universities

The only comparable competition we know of is Tufts University's "Do It In The Dark" competition where dorms competed against each other on cutting back electricity costs.

Other Institutions

We are not aware of any other institutions that have held such a competition.

Getting Started

In order to get started, someone must present this idea to George McPhail who runs the energy management system on campus to ask for his assistance in carrying out such a competition. Connie Bisson and the Environmental Council should be informed and it is likely they will play a large role in the project. Finally, the space heating and cooling group of the winter term 2003 Carbon Neutral Middlebury class should be contacted if any assistance is needed in running the competition.

II.3.1.e – Window replacement and upgrade

Summary data

Index rank	Payback time (years)	Annual tonnes CDE	Total (cost) or benefit per tonne
18	21.4	220	$ 25

The energy savings associated with buying new windows is quite high on a house due to the reduced need to heat and cool. This savings can clearly be applied to a dormitory or academic building. For example, an old wooden framed, single paned window loses approximately 1.2 BTU/hour. Double paned, argon insulated, vinyl framed windows will reduce this loss to 0.34 BTU/hour.[10] Currently, a number of the Middlebury facilities have old windows, including Allen, Stewart, Forest, Munroe, Freeman International Center and Warner, as well as a number of smaller buildings such as both Hillcrest buildings. Middlebury College could commit to retrofitting these buildings with energy efficient windows (U value< 0.35) by a certain time, such as 2008, instead of waiting until the facility is renovated. In addition, when renovating a building, policy should mandate that the windows are updated if old and inefficient. For example, Stewart was renovated the summer of 2000, but all windows still have old, single paned glass. In addition, three years passed from when Battell was renovated to when the windows were replaced. Window upgrades should be a priority during renovations. It should also be noted that historic buildings can have specially made windows that are thermally insulated. For example, Old Chapel, Painter and Star have had most of the their windows designed to maintain the historic integrity of building and save energy using thermal insulation. The following strategy provides the case study of Battell, and outlines the case for Allen, Forest, Stewart, Munroe and Warner.

Timeline

Implement policy immediately. Plan to renovate all older model windows by 2008. The ISES reports, which reviewed the quality of all buildings on campus in the spring of 2000 (found in the Service Building), outlines which buildings are most in need of new windows.

Magnitude of Potential GHG Reduction

By switching to new windows from single- paned models with a U value of 1.2 BTU/hour, the CO_2 emissions associated with newer models would be reduced by 75%. Recently, Battell was renovated with new windows, replacing 181 single paned wood sash windows with Harvey Industries double-hung, vinyl, double pane, low-emissivity argon windows. For a building the size of Battell, the CO_2 reduction was calculated to be approximately 40 metric tons/year. Thus, if Forest, Allen, Munroe, Stewart, and Warner were all renovated with new windows, the estimate reduction would be approximately 220 tons/year (see appendix for calculation). Freeman International Center and campus houses needing new windows were eliminated, because of lack of specific data regarding the windows (how many windows in each building, size of the windows etc.).

Benefits and Costs

Fixed Cost and Benefits

This past summer Middlebury paid $54,300 for window replacements in Battell. The payback time for this installation will be approximately 21 years (annual savings of $2538/year). However, over a 50-year period, installing these windows will save Middlebury approximately

$73,650. If all windows of the five key buildings (Allen, Forest, Munroe, Stewart and Warner: approximately 684 windows) were the same size as the Battell windows (15 sq. feet), and the price per window was fixed at the same price as Battell ($300/ window) then replacement in these 5 buildings would have an estimated cost of $205,200. The payback, however, would be an estimated 21 years, with an annual savings of $9,597. Thus, over a 50-year period, Middlebury will save $278,300.

Variable Cost or Benefit

$0

Other Costs and Benefits

Social. More comfortable room temperatures for students, faculty, and staff due to thermostat control

Public Relations. Middlebury could advertise that all windows have a U value lower than 0.35 or that they are all Energy Star windows to emphasize environmental awareness and comfortable room temperatures.

Possible Financing Mechanisms

Occasionally Energy Star products have special rebates on their products

Stakeholders

On campus

Policy makers, such as John McCardell, Ron Liebowitz, and Bob Huth, must commit to window replacements, and create a policy stating that during all renovations, old windows will be replaced. Furthermore, Harold Strassner is the customer service representative at Middlebury, he was responsible for the window replacements in Battell, and he may be helpful in attaining more information about the costs of special design windows.

Students, Faculty, Commons

Off campus

Clover State Construction in Ferrisburg, VT (Window contractor used for Battell in summer 2002), contact person, Marcel Bumet, 802-877-2102

Sprague Energy: oil provider

Examples from elsewhere

Other Colleges and Universities

It is well known that good windows are essential to maximize energy efficiency, therefore it is probable that the majority of colleges and universities use energy efficient windows when remodeling.

Other Institutions

All new buildings and nearly all institutions choose energy saving windows due to their cost-effectiveness.

Getting Started

Harold Strassner from Facilities Management facilitated the change in Battell, so he might be useful in coordinating this effort. The window company Middlebury used in the Battell renovation was Clover State Construction Inc (contact person: Marcel Bumet). The sooner Middlebury chooses to replace windows, the sooner it will begin saving money and reduce CO_2 emissions.

II.3.2 Reduction of oil use associated with water heating

Summary of Strategies

a. ***Shower head replacement***

b. ***Solar water heating for houses and dormitories***

II.3.2.a – Showerhead replacement

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
26	3.2	50	$ 82

Changing a person's daily habits is extremely hard. Not even effective education can ensure that a person will in fact change his or her behavior and act in an environmentally conscious way. By installing low-flow showerheads, Middlebury College will not only be complying with Vermont Law but will also help students live more environmentally friendly lives. According to Vermont State Law, Middlebury College must install low-flow showerheads in any new construction project, and switch to low-flow showerheads if a conventional showerhead needs maintenance in an older building. Therefore, any construction that has occurred on campus within the last seven years, any dormitories that have been renovated within the last seven years, or any showers that have required maintenance in the last seven years all have low-flow showerheads. These low-flow showerheads translate into an enticing idea. For example, student Joe likes the idea of conserving hot water but feels that cutting his shower time by 40% is not worth the water and energy savings. With low-flow showerheads in his shower, however, he could take his usual amount of time showering and still use 40% less hot water than he would with the old conventional showerhead. This savings in hot water directly turns into savings in heating needs, which means we burn less oil and thus save money. Not only do these savings help finance the state-required low-flow showerheads, but by going beyond the requirement of the law Middlebury College would be showing the community how seriously we take environmental laws, and how we are willing to be environmentally aware.

Currently, all of the showerheads on our campus are low-flow, but many low-flow valves have yet to be installed. Approximately 100 low-flow valves are scheduled to be installed in the next few years.

Timeline

The college does not wait until a building needs to be renovated or a showerhead needs maintenance. Instead, we are currently replacing these valves in the course of their regular maintenance.

Benefits and Costs

Fixed Cost

The cost for each new low-flow valve is $141.

Variable Cost or Benefit

Every three months, according to the Department of Energy, a low-flow valve saves $11 in water heating. There are no operating costs because the low-flow showerheads accomplish the same task as conventional showerheads. In addition, current Vermont law requires the use of low-flow showerheads when an old one is replaced.

Other Costs and Benefits

Environmental. A large portion of our hot water needs will be reduced indicating that less fuel will be needed to produce steam to heat the hot water. In addition there is less wastewater used per shower.

Social. When low-flow showerheads were first installed in some of the buildings, some students did complain that it took longer to get the shampoo out of their hair, however, since that time the student body has adjusted and no longer complains about the lower flow.

Public Relations. By going beyond our compliance with Vermont State Law, Middlebury College will be showing the state as well as the community that the college takes the state's environmental laws seriously.

Cross-cutting areas and synergies. Saves on electricity in campus houses that have electric hot water heaters.

Possible Financing Mechanisms

Since the school will eventually have to pay to replace each showerhead on campus, then there will be no net loss of money.

Stakeholders

On campus

Students
Staff
Facilities Management - Harold Strassner

Off campus

Delta Showerhead Company
Sprague Energy

Examples from elsewhere

Other Colleges and Universities

Every building that has been built on a college campus in Vermont in the last seven years has low-flow showerheads.

Other Institutions

Any recent major construction in Vermont must have low-flow showerheads.

Getting Started

Contact Harold Strassner (x2538) of Facilities Management and he will be able to replace older showerheads with the new low-flow showerheads and low-flow valves from his stockpile and will also be able to order more of these. However, some investigation on identifying the showerheads that need upgrading may still require some work.

II.3.2.b Install solar water heating systems on campus houses and dormitories

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
33	11.1	5	$ 567

Currently most on campus houses are heated using domestic water heaters with an oversized 115 gallon holding tank (ISES).[13] These water heaters use large amounts of electricity in order to heat the water. Much of this electricity could be saved if a solar water heating system was put in place.

Solar water heating systems use the suns energy to heat an anti-freeze solution running through black, specially designed, panels placed on the roof of a building. This anti-freeze solution is then used to heat water in a storage tank. Since we live in a cold climate that is cloudy for much of the year, solar water heating cannot be relied upon for all of our water heating needs. There is a temperature sensor in the hot water tank, if the water is not hot enough it is heated on demand by a fossil fuel powered backup heater. This system cuts the cost of water heating by 65-70% (Back East Solar[14])

Using Weybridge house as an example, (simply because Weybridge House happens to have a meter on their water heater), we find that each year 13,469 kWh of electricity are used for water heating. This is almost half of the total 31,292 kWh of electricity used by Weybridge House.[2] Assuming that 7.11e-5 tons of CO_2 are emitted for every kWh of electricity that we purchase,[15] we find that by switching Weybridge House to solar water heating would save 0.94 tons of CO_2 per year. This is lessened by the fact that a fossil fuel heater to make up for the amount of heat that can't be generated by the solar collectors must supplement solar water heating. This amount varies greatly depending on the amount of heat generated by the collectors. The actual tons of CO_2 saved would be lower than this number. Also, since heating water with fossil fuels is much more effective than heating using electricity, we would recommend upgrading from electric hot water heating to other systems for all units not on the core campus system. Since we have no way of estimating the amount of fossil fuels that would need to be burned to supplement the solar water heating system we can only give a high limit of 0.94 tons of CO_2 per year.

There is also a monetary saving associated with switching to solar water heating. Using electricity to heat water costs the college $1373 per year.[2] If the cost of water heating by the college cut by 65% the college would see a monetary savings of $892.00 per year. The initial cost of installing a solar water heating system would be significantly higher than that of installing an electric water heater. The cost of buying and installing a new electric water heater is between two and three thousand dollars,[13] while a new solar water heating system costs around eight thousand dollars for parts and installation[14]. However, this would pay for itself within10-15 years. This system has a lifetime of over 30 years, so the college would make a net profit by switching to solar water heating.

There are several problems associated with solar water heating. The first is that solar water heaters require direct sunlight and a large southern exposure. This eliminates many of the campus houses (including Weybridge) from consideration for solar water heating, because trees surround the south side of the house. However, there are many houses on campus that do have adequate southern exposure to support solar hot water. It should be noted that the fact that a house may not have a south facing roof does not mean that it can not be equipped with a solar water heating system, because mounts can be installed on an east or west facing roof to provide adequate southern exposure.

It would be best to install solar water heating systems on houses that are used in the summer as well as the winter. Heat collectors work best in the summer months, since there is not a large loss of heat to the surrounding air. Therefore, houses that are only used in the winter months would not be good candidates for this project.

Efficiency Vermont, which we work with on many projects, would most likely be able to supply us with financial incentives based on the amount of electricity that would be saved through this installation of a new solar water heating system. They should be consulted before going ahead with this project.

Dormitories: Currently Middlebury College heats water in most of its dormitories using steam created in the physical plant. This steam is pumped through pipes from the physical plant to the buildings, where it is condensed on a heat exchanger, which transfers the heat into water to be used throughout the building. This process is fairly inefficient (however it is more efficient than the electric water heaters used in the houses). The total efficiency of turning the #6 oil burned in the physical plant to hot water is about 65%.[2]

We do not currently have an estimate of the cost associated with installing a solar water heating system on a dormitory. We do however have an estimate of the cost savings per year and the total amount of CO_2 saved per year. We estimate that the college will save about $600 per year on water heating costs and 11 metric tonnes of CO_2 per year (see Appendix). The CO_2 savings are considerably larger than the cost savings because the price of oil is low and the CO_2 emissions associated with the burning of #6 oil are very high.

In summary we see that a greater cost savings is gained by converting campus houses to solar water heating, and more CO_2 reductions are found by installing solar water heating on dormitories. This is because of a number of factors. One is that it is expensive to heat water using electricity, this is because of the inefficiency due to converting the quality of energy. Greater CO_2 saving are found in converting the dormitories to solar water heating because of the large amount of CO_2 emissions associated with the burning of #6 oil. However, oil has been relatively inexpensive in recent years and is a much more efficient way of creating heat energy than electricity. Therefore the monetary savings of installing solar water heating systems on college dormitories is minimal.

In the end it is most likely more effective to install solar water heating systems on campus houses, if not for CO_2 savings, then simply for energy and monetary savings. Their installation on dormitories should be viewed as low priority. Accordingly, for the summary calculations below, we assume that this will be undertaken for five small campus houses with the adequate southern exposure.

Timeline

Most College owned houses are in need of new water heaters within the next 5 years according to the ISES report.[13] Instead of simply replacing the old systems with new electric water heaters the College could use this as an opportunity to install a solar water heating system in five small houses.

It is also recommended that many of our current steam to hot water heat exchangers in dormitories be replaced soon.[13] Instead of replacing the heat exchangers, we could instead install a solar water heating system. This could happen on select dorms within a few years.

Magnitude of Potential GHG Reduction

If installed in fives houses, the College would reduce its emissions by 5 MTCDE/year. This number can be extrapolated to other houses. Clearly, the more houses on which the College installs solar water heating systems, the more carbon dioxide is saved. Eleven tonnes of CO2 per year could be saved with the installation of a solar water heating system on Hepburn dormitory. This is a much larger reduction than can be found by installing a system on campus houses.

Benefits and Costs

Fixed Cost

Startup costs would be about $10,000 for a large system for a house. This cost would vary with the amount of water needed. Cost would have to be estimated on a per building basis. Some of this initial cost can be differed by Efficiency Vermont depending on the amount of electricity that would be saved.

No company would provide an estimated cost of installing a solar water heating system on a dormitory. It would likely be high due to the requirement of additional piping and because the system would be massive.

Variable Cost or Benefit

The cost savings associated with the installation of a solar water heating system on one house would be approximately $900 per year.

The cost saving associated with the installation of a solar water heating system on Hepburn dorm would be about $600 per year.

Other Costs and Benefits

Environmental. Large reduction in energy use and carbon emissions.

Public Relations. This would be good advertising for our school. Putting solar water heaters on our buildings is a statement. There is the possible negative visual impact, but it is unclear if this would be a problem.

Cross-cutting areas and synergies. Clearly putting solar water heaters on campus houses would affect electricity use and therefore this proposal is cross-cutting between electricity and space heating and cooling.

Possible Financing Mechanisms

Efficiency Vermont and other organizations have programs to give financial incentives to institutions planning to purchase green technologies. These incentives are based on the amount of electricity that would be saved and therefore are only a viable option for installation of solar water heating system on campus houses currently using electric water heaters.

Stakeholders

On campus

Administration
Students
Facilities management
Facilities planning

Off campus

Vermont Solar
Back East Solar
Efficiency Vermont
Vermont Yankee Nuclear Power
Community members

Examples from elsewhere

Other Colleges and Universities

Tufts University put up a solar water heating system on one of their campus houses as a part of their climate change initiative.

Other Institutions

Unknown.

Getting Started

The first people to call would be one of several solar energy companies in order to get an exact estimate of cost. Back East Solar (www.backeastsolar.com) and Global Resource Options (www.GlobalResourceOptions.com) are excellent places to start. Once an estimate from these or other companies is received, Efficiency Vermont should be contacted in order to investigate the options for financial incentives.

II.4 Future Considerations

II.4.1. Natural gas support: Middlebury policy[11]

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
11	1.8	3,000	$ 52

Natural gas is widely accepted as the most environmentally friendly fossil fuel. Relative to burning coal, it produces half the amount of CO_2. When comparing its direct emissions to #6 oil, natural gas produces 35% less emissions. Thus, switching to natural gas would have an impact on the carbon footprint of Middlebury in terms of CO_2 associated with space heating and cooling, as well as a potential offset value if Middlebury were a major player in bringing natural gas to the area. Clearly, there are many stakeholders in this initiative. However, Middlebury could make a political statement that it is committed to using natural gas, if Vermont Gas proposes a plant that could supply the College.

Timeline

Five years ago, there was a major initiative by Southern Vermont Natural Gas to develop natural gas lines in southeastern Vermont. Two plants were going to be built—one in Rutland, Vermont and the second in Bennington, Vermont. These plants were going to be linked together, as well as to natural gas pipelines in Albany, NY. They would have been capable of providing 1350 MW of energy, which is more energy than the entire state of Vermont needs. Eventually, the plan would have led to a pipeline providing both Middlebury and the Killington area with natural gas. There was major opposition to this project by the local communities.[16] In the future, however, Vermont Gas, which currently provides natural gas as far south as Shelburne, is considering building a plant that might be able to provide Middlebury with this resource. The plant would be much smaller, on the magnitude of 250 MW. Although still quite tentative, the company is searching for investors to fund the project when other energy companies go offline. There is therefore no official time line for making a statement about supporting natural gas, until an initiative has been publicly announced. However, it is important that the Administration becomes informed immediately about the costs and benefits of natural gas, so they have the tools necessary to make an informed decision.

Magnitude of Potential GHG Reduction

The reduction would be approximately 3,000 tons MTCE, a 10% reduction from #6 oil emissions (0.008 tons/therm). This number is based on a calculation including both upstream and downstream emissions associated with natural gas, and therefore includes the impact of methane and N_20 on climate change. It should be noted that if Middlebury would choose to draw the line at direct emissions, the associated reduction would be about 35%. It also takes into account that the colleges Vermont Gas currently supplies have interruptible service, which means that during extremely hot or cold days, Middlebury would not be able to access the gas and must burn oil. We hypothesized that this would happen 30 days each year, and also used the calculation for oil that would include upstream and downstream emissions (0.013 tons/gallon).

Benefits and Costs

Fixed Cost

To retrofit three of the four boilers to burn natural gas would cost approximately $300,000 ($100,000 each).

Variable Cost or Benefit

There would be no additional operating costs associated with a switch to natural gas. There would, however, be an overall savings of 4.5 million dollars over a 30-year period. The cost/ton would be a benefit to the college: -$50/ton (this estimate is based on an estimate of current prices for natural gas, $4-5/therm given by Scott Harrington[17] at Vermont Gas, (802) 863-8899 ext. 338). For oil, the 2000 estimate was used, $0.80/gallon.

Other Costs and Benefits

Environmental. Two environmental hurdles such a project might face are the aesthetic concern of the pipeline and possible negative effects related to leakage. The solution is temporary, for there are still high emissions associated with natural gas burning, and eventually the College would need to switch to a renewable resource. However, if given the option between burning oil and natural gas as a fuel source, the latter is the choice that has lower carbon emissions and a cheaper price.

Public Relations. Major opposition by local community initially. Overtime, Vermonters might approve of this fuel source.

Possible Financing Mechanisms

Not applicable

Stakeholders

On campus

John McCardell, President
Ron Liebowitz
Bob Huth
Michael Moser, Central Heating Plant Manager
Boiler operators and managers

Off campus

Sprague Energy: oil provider
Vermont Gas Co: natural gas provider
Local community

Examples from elsewhere

Other Colleges and Universities

Many other universities and colleges have far lower emissions associated with space heating and cooling due to the use of natural gas. Examples include the majority of colleges in cities where it is an option, such as Tufts University, University of Vermont, and Saint Michael's College.

Other Institutions

All major cities have the option of natural gas, and therefore utilize this fuel source. It is recognized by major environmental groups as the best fossil fuel available.

II.4.2. Geothermal Heat Pumps

Geothermal heating and cooling uses a renewable resource found throughout the world -- the ground. At a depth of ten feet below the surface of the Earth, the soil remains a relatively constant temperature, plus or minus a couple of degrees, year round. In most places around the world this temperature is somewhere between 45°F and 70°F. Geothermal heat pumps (GHPs) take advantage of this temperature range by running plastic pipes underground filled with water or a mixture of water and antifreeze. In the wintertime when the outside temperature is cold, the temperature of the ground is a constant temperature between 45°F and 70°F. To heat the building, the GHPs take the heat from the ground and concentrate this heat in the pumps. This heat is then circulated throughout the building. The reverse process is used to cool a building. When a building is warmed up in the summertime, the GHPs pull the heat from the building and carry this heat through the system where it is cooled in the relatively cool earth, which is then used to cool the building. These systems have an average lifespan of twenty years, but require virtually no maintenance during the span and even pay for themselves usually in less than five years. In addition, the heating and cooling GHPs provide are less noisy than most heaters and every room has its own comfort control. Also, the heating pipes in the walls can take excess heat from the sunny side of a building and use it to heat the colder shady side of that building. The heating pipes used to disperse this heat throughout the building can use heat given off by appliances such as a refrigerator. Finally, GHPs can also provide for the hot water needs of a building ("Geothermal"[18]). By using the Earth as a source of heating and cooling, the energy consumption for a building is greatly reduced and thus emissions associated with this heating are also reduced.

This technology is currently being used in 500,000 buildings ranging in size from homeowners to large institutions such as Fort Polk Army Base in Louisiana, Skunk Creek Conoco station in Sandstone Minnesota, the Georgia Institute of Technology, the Great River Medical Center in Iowa, and other large commercial buildings ("Geothermal"). Therefore, the technology is available and has been proven to work. However, this technology has not yet been developed to its potential. Electricity is needed to power the process and currently has a lifespan that is less than the boilers we use. Due to this increase in electrical demands and the short lifespan, we did not feel that GHPs were a viable solution to provide heating needs for buildings that are already part of a rather intricate heating system. While GHPs are not currently viable for Middlebury College, they should be looked into when a new building of any size is being built on campus. The Department of Energy is excited about this technology and is investing a lot of time into advocating its use throughout the country. GHP technology has recently taken off, and the first quarter of 1998 sales grew by 24% ("Geothermal"). With all of this attention these systems are receiving, GHPs may be a viable option to provide heating by the time designs for a new building at Middlebury College are proposed.

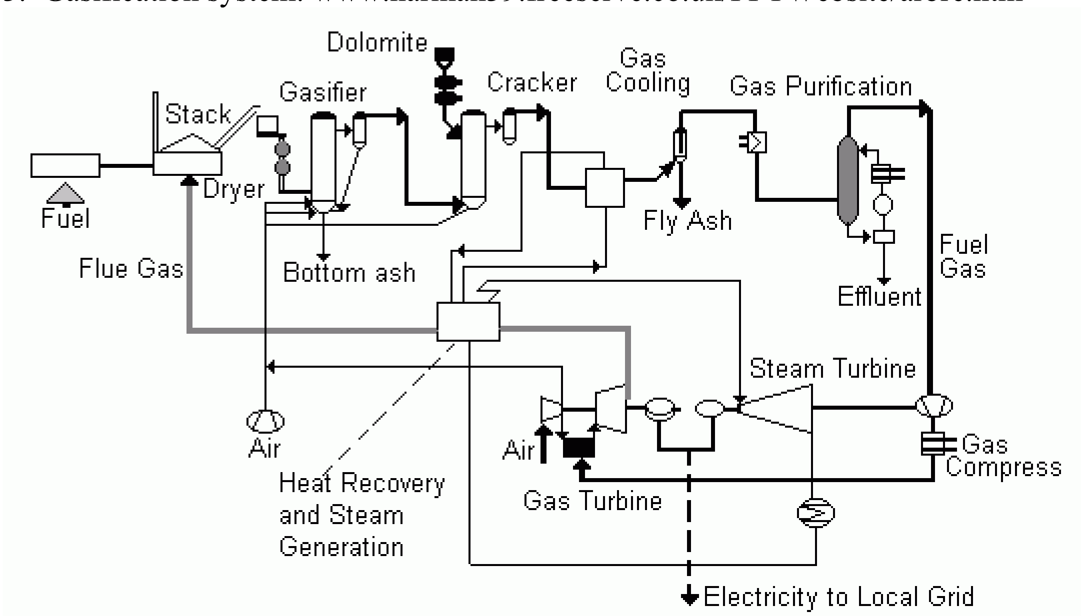
II.5 References and Notes

1.

Fuel	#6 oil	#2 oil	propane
Gallons	1,694,233	390,599	40,759
Conversion (tonne CO2/gal)	0.013	0.0128	0.0072
CO2 emission	22025.03	4999.672	293.4648
		Total	**27318.17**

*This data is based on 2000 data of the emissions inventory.

2. These figures were given by Michael Moser, Central Heating Plant Manager, Middlebury College.
3. Gasification system: www.harman39.freeserve.co.uk/FFTWebsite/arbre.htm



"The gasifier itself is a circular steel vessel. The wood chips are fed into the hopper, air is injected and the woodchips tossed around, so they mixed with the oxygen in the air. The wood/oxygen mixture is heated to a high temperature so that the wood gives off moisture and undergoes thermal decomposition. This process produces steam, volatile gases and a tarry substance called char. The volatile gases…(raise) the temperature of the gasifier to 850° C. In the blast tube, the amount of oxygen is limited, this results in a product called syngas (energy value 5.4 MJ per cubic meter), which is mainly carbon monoxide, hydrogen and methane."

4. Figures for cost/ton for landfill and composting were verified by Norm Cushman, Facilities Management, Middlebury College.
5. $24/ton, ash fertilizer price: www.extension.umn.edu/mnimpact.asp?projectID=3005.
6. Paul Frederick, Vermont Department of Forests, Parks and Rec: 802-241-3698
7. George Robson, Natural Products Specialist, Dept. of Economic Development http://www.thinkvermont.com, (802) 828-5241,George.Robson@state.vt.us
8. http://www.mwcc.mass.edu/HTML/FWP/conversion.html#top
9. http://www.es.wapa.gov/pubs/esb/02jun/esb611.htm

10. "Passive Solar Heating, Cooling and Daylighting." U.S. Department of Energy: Office of Energy Efficiency and Renewable Energy. 25 October 2002. http://www.eren.doe.gov/RE/solar_passive.html 29 January 2003.

11. "Passive Solar Design." Army Team C41EWS: Command, Control, Communications, Computers, Intelligence, Electronic Warfare & Sensors. http://www.monmouth.army.mil/cecom/usag/dpw/ermd/energyprograms/solar.htm 29 January 2003.

12. "How to Save Energy." Bonneville Power Administration: Energy Efficiency. 2003. http://www.bpa.gov/Energy/N/energy_tips/save_energy/ 29 January 2003.

13. ISES Analysis Report, ISES Corporation, 2000.

14. Back East Solar:www.backeastsolar.com

15. Figures provided by Lori Del Negro, Visiting Assistant Professor of Chemistry and Biochemistry, Middlebury College, 2003.

16 . "Understanding the Proposed Billion Dollar Northern Gas Project for South western Vermont." Annette Smith, www.vtce.org/NewsClips/understanding072399.html

17. Scott Harrington, Industrial Account Representative, provided the majority of the information on the future of Vermont Gas Co.: 802-863-8899 x338

18. "Geothermal Energy Program." U.S. Department of Energy: Office of Energy Efficiency and Renewable Energy. 15 March 2002. http://www.eren.doe.gov/geothermal/geoheatpumps.html 29 January 2003.

II.6 Appendix

II.6.1 Window calculation:

Assumptions:

1) U value of old windows = 1.2 BTU/hour
2) U value of new windows = 0.34 BTU/hour
3) Air infiltration of old windows = 0.1 cfm/ft^2
4) Air infiltration of new windows = 0.05 cfm/ ft^2
5) Window size: 14.8 ft^2/ window
6) Average temperature differential = 30˚F (www.weather.com)
7) #6 fuel oil = 140,000 BTU/gallon
8) CO_2 emitted = 0.011 CO_2 / gallon (accounts for upstream, downstream CO_2, N_20, and methane)
9) # 6 fuel oil = $0.80/gallon (2000 rate)
10) $300/window (removal, installation)

Sample calculation: Battell dormitory

1))OLD: Window heat loss: (U value)(area of window)(Δ T)

Transmission heat loss/hour = (1.2 BTU/hr)(14.8 ft^2)(30˚ F)=532.8 BTU/hr

Infiltration heat loss/hr = (cfm)(1.08)(Δ T)= (0.1 cfm)(1.08)(30)= 3.24 BTU/hr

Total heat loss = 532.8 + 3.24 = 536.04 BTU/hr

Annual # 6 fuel oil use formula (Engineering cookbook, see Mike Moser):

(536.04 BTU/hr / 30 * 140,000 * 0.65)(8000 HDD/yr)(24)(0.65)= 24.5 gal/yr
= (24.5 gal/year)(181 windows) = 4435 gallons/year

CO_2 emissions= 4435 gallons * 0.013 metric tons CO_2/gallon = 57.7 tons of CO_2/ year

2) NEW: Window heat loss: (U value)(area of window)(Δ T)
Transmission heat loss/hour = (0.34 BTU/hr)(14.8 ft^2)(30˚ F)=151 BTU/hr
Infiltration heat loss/hr = (cfm)(1.08)(Δ T)= (0.05 cfm)(1.08)(30)= 1.62 BTU/hr

Total heat loss = 151 + 1.62 = 152.6 BTU/hr

Annual # 6 fuel oil use formula (Engineering cookbook, see Mike Moser):

(152.6 BTU/hr / 30 * 140,000 * 0.65)(8000 HDD/yr)(24)(0.65)= 6.97 gal/yr
= (6.97 gal/year)(181 windows) = 1263 gallons/year

CO_2 emissions= 1263 gallons * 0.013 metric tons CO_2/gallon = 16.4 tons of CO_2/ year
ΔCO_2 = 57.7 – 16.4 = 41.3 metric tons CO_2

For Warner, Stewart, Allen, Forest, and Munroe (assume all windows to be 14.8 ft^2) (Note: Munroe has had some storm windows installed, therefore this estimate might be a slight overestimate).

Window # = 684
Allen: 60
Forest: 240
Munroe: 112
Stewart: 84
Warner: 188

(24.50 gal/yr)(684 windows)=16,758 gal/year
(6.97 gal/yr)(684 windows)= 4767 gal/yr

OLD:
CO_2 emissions= 16,758 gallons * 0.013 metric tons CO_2/gallon = 218 tons of CO_2/ year
NEW:
CO_2 emissions= 4767 gallons * 0.013 metric tons CO_2/gallon = 62 tons of CO_2/ year

ΔCO_2 = 218- 62 = 156 metric tons CO_2

II.6.2 Showerhead Calculation:

Assumptions:

1) Average Middlebury student showers every other day.
2) Average shower stall is used by 7 students
3) Average shower lasts 8 minutes
4) Students are on campus 36 weeks of the year
5) Conventional showerhead uses 3.5 gallons/minute
6) Low-flow showerhead uses 2.0 gallons/minute
7) BTU = heat required to raise the temperature of 1 lb of water 1ºF
8) 1 lb of water = 0.1198 gallons of water
9) Water must be heated from 60ºF to 120ºF for hot water needs
10) #6 fuel oil = 140,000 BTU/gallon

11) 0.013 tonnes CO_2 = 1 gallon of oil

Sample calculation for one showerhead:

Difference in showerhead efficiency: 3.5gallons/minute – 2.0gallons/minute = 1.5gallons/minute

Gallons of hot water used per day for a shower stall:

(1.5gallons/minute)(8min/person)(3.5 people) = 42 gallons per day

Gallons of hot water used per year:

(42gallons/day)(7days/week)(36weeks/year) = 10584gallons/year

Lbs. of hot water: (10584gallons/year)(1 lb./0.1198gallons) = 88347 lbs./year

BTU's: (88347 lbs./year)(60ºF) = 5300820 BTU's/year

Gallons of oil: (5300820 BTU's/year)(gallon oil/140000 BTU's) = 37.9 gallons oil/year

Savings of oil: (37.9 gallons oil/year)($0.69/gallon oil) = $26

Savings of tonnes of CO_2: (37.9 gallons oil/yr)(0.013 MTCDE/gallon oil) = 0.5 MTCDE/yr

Energy used on heating water in Hepburn Hall:

-Taking the example of Hepburn Hall, which has 160 residents.

-Assuming that all of Hepburn's hot water is used in students showering.

-Assuming that ½ of the students living in Hepburn take a shower each day.

-Assuming that they take 5-minute showers.

-Assuming that the average non-low-flow showerhead uses 5 gallons of water every minute.
http://www.conectiv.com/cpd/your_home/energy_tips/shower.cfm

80 students * 5 minutes/student * 5 gallons/minutes= 2000 gallons of hot water used every day.

-Assuming that the water starts at the ambient ground temperature of approximately 60 degrees F

-Assuming that the water is heated to 120 degrees.

-Assuming that 70% of the water coming out of the showerhead is at 120 degrees and the rest is unheated.

-Taking the fact that a BTU is defined as the amount of energy needed to heat one pound of water one degree F. Also using the fact that 1 pint of water weighs one pound, and there are 6.66 pounds in a gallon.

2000 gallons/day * .70 * 6.66 pounds/gallon * 1btu/pound degree F * 60 degrees F = 559440 BTU's per day used for showering in Hepburn.

-Assuming a 65% efficiency rate of the physical plant heating system. (Michael Moser)

-Taking the fact that each gallon of #6 oil burned gives off 150,000 BTU's of heat.

-Assuming that installing a solar water heating system reduces the cost of water heating by 65% throughout the course of a year, and assuming that since cost is directly related to CO_2 emissions. (This is true for Middlebury College since our costs are associated with buying # 6 oil)

-Using the conversion .013 metric tones of CO_2/gallon of # 6 oil.

559440 BTU's/day / 150,000 BTU's/gallon *.013 tonnes CO_2/gallon of oil * .65 reduction in CO_2 emissions = .0315 metric tones of CO_2/day

-Assuming that the school currently pays $.69/gallon of #6 oil.

559440 BTU's/day * 150000 BTU's/gallon * $.69/gallon * .65 reduction in cost = $1.67/day

This means a savings of:
1.67*365= $609/year

CO_2 savings of:
.0315*365 = 11.5 metric tones CO2/year

III. Electricity

III.1 Greenhouse Gas Emitting Activities

Carbon equivalent emissions are associated with the current generation of *purchased* and *campus-generated* electricity consumed by Middlebury College. The College purchases electricity from off campus utilities (currently from Central Vermont Public Service/CVPS), in addition to co-generating electricity on campus from residual heating steam forced through electrical generators.

Table III.1. Electricity consumed in 2001 and 2002.

2001			
Purchased Electricity		Co-Generated Electricity	
Total Cost	Total kWh	Savings	Total kWh
$ 1,512,891	16,936,693	$ 273,313	3,068,314

2002			
Purchased Electricity		Co-Generated Electricity	
Total Cost	Total kWh	Savings	Total kWh
$ 1,491,111	17,070,400	$ 235,868	2,751,380

Over the ten year period from fiscal year 1990 through 2000, purchased electricity on average accounted for 39.85% of total College expenditures on energy. In 2002, 17,070,400 kWh of electricity purchased from CVPS for $1,491,111 emitted 1,416 MTCDE into the atmosphere (Table III.1).

It is important to note here that the College considers co-generated electricity a fortunate byproduct of the College's space heating and cooling system. Co-generated electricity accounted for only 13.88% of the College's 2002 total electricity portfolio, but generated $235,868 in savings that would have been spent to purchase required electricity from CVPS. It is not necessary to calculate the MTCDE associated with Middlebury's co-generation, because the heating oil is burned anyways, and excess steam is "blown by" the generator turbines. The emissions generated by the #6 oil are accounted for in the Space Heating and Cooling Sector.

III.2 Primary Stakeholders

Every single member of the Middlebury College community is responsible for their level of electricity consumption, and should be – by default – responsible for decisions about where their electricity comes from and how it is generated. Especially concerned are: Campus Sustainability Coordinator, Heating Plant, and Facilities Management/Planning, Treasurer, Budget Office.

III.3 Summary of Objectives

1 Reduce electricity consumed by Middlebury College.

If we reduce the amount of electricity consumed by Middlebury College, we (1) increase the proportion of total electricity generated on-campus, (2) *very significantly decrease purchased electricity costs*, (3) decrease statewide demand for electricity, and (4) discourage the development of new off-campus power plants and need for larger transmission lines intended to meet increasing demand.

2 Reduce the carbon emissions associated with purchased (off campus) and generated (on campus) sources of electricity.

In addition to reducing total electricity consumption which will inherently reduce carbon emissions associated with College electrical needs, demanding cleaner, carbon-neutral sources of electricity will further reduce the carbon footprint of Middlebury College's electricity consumption. We advocate the development and use of renewable and environmentally/socially-sustainable electrical sources whenever and wherever possible to accomplish the goal of carbon neutrality.

3 Offset existing carbon emissions associated with College electricity generation and consumption.

We recognize that achieving true carbon-neutral electricity generation and consumption means switching to totally carbon-neutral sources (like solar or wind power) and fundamentally changing the consumption behavior of students, faculty and staff, in addition to designing more electricity-efficient facilities. This will take time. Until then, we must offset carbon emissions associated with the on- and off-campus generation of electricity we consume.

III.3.1 Reduce electricity consumed by Middlebury College

Summary of Strategies

a. Residential Electricity Conservation Education

b. Compact Fluorescent Bulbs in all student dorm rooms

c. Efficient Computer Use

d. Vending Misers on campus vending machine

III.3.1.a – Residential Electricity Conservation Education

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
8	0.0	80	$ 1,254

ROOM/COMMONS LEVEL SOLUTION, Short- and Long-Term. An overall 10% reduction in total electricity consumed on campus from FY-2002 to FY-2005, could be accomplished by an incentive-based, residentially-focused electricity conservation education effort that reduces electricity consumed in each Commons by 15% of the previous year's consumption level.

This will be a huge challenge, since only about 25% of total campus electricity is consumed by residential buildings. To get a 10% campus-wide reduction in electricity consumption, accomplished through a 15% reduction-per-year in only residential consumption, would mean students must reduce electricity consumption in their rooms by 40% over a three-year period. The thinking here is that residentially-based conservation efforts will mobilize a change in student attitudes and behavior with respect to electricity elsewhere on campus, and initiate a call for change all over campus – in classrooms, sports facilities, support buildings, and especially dining halls (which, at our best educated guess based on available data, represent approximately 40% of campus electricity consumption).

PROCESS: The administration "challenges" each Commons to reduce its overall electricity consumption by 15% each year, for 3 years. $3500 is made available by the administration to purchase 20 Kill-a-Watt© Watt-Hour meters for each of the five Commons offices (100 total). These meters are low-cost, portable watt-hour meters that plug directly into a wall outlet, and measure the watt-hours consumed by appliances plugged into the watt-meter. 20 watt-meters per commons is based on the need for 3-4 watt meters (one per each outlet) to measure the total electricity consumption of a typical student room, and 5-6 students within a Commons wanting to learn their room's consumption simultaneously. Each Commons elects/appoints a student Carbon Neutrality Representative (CNR), who sits on the committee successor to the CRI, and manages Commons-level projects such as this *Electricity Conservation Education*. The CNR distributes watt-hour meters to interested students within their Commons so that students can track their room's electricity consumption and identify "guzzlers" and "power drips." The CNR organizes inter-dorm/intra-commons conservation competitions, and helps lead energy conserving projects like appliance upgrades and retrofits.

INCENTIVE: If the Commons has reduced its overall electricity consumption by 15% or more by the end of each school year, it is awarded 50% of its calculated electricity savings, to reinvest in carbon neutral projects or to spend as the Commons sees fit. The College will invest the remaining 50% of savings in campus-wide carbon-neutral projects (like solar paneling, purchasing offsets, or upgrading boilers). Accompanying this strategy section is a portfolio or toolkit of references for CNR's to use as they cooperatively design effective conservation education projects and programs for their Commons. CNR's would meet as a group (in addition to CRI meetings) to discuss conservation projects, trade lessons learned, etc. The consumption benchmark from which each Commons would have to drop 15% to qualify for the incentives, would be based on the previous year's consumption.

Timeline

Some student representatives to the CRI from each Commons already exist. More could be added. Commons lacking a CNR need to appoint or elect one, and existing CNR's should be given an opportunity to choose whether or not they are prepared to accept the additional, above-stated responsibilities that would be added to that leadership description. Watt meters should be purchased and deployed immediately. We intend for this conservation initiative to last for 3 years, but this timeline will depend on the efficacy of conservation efforts. If the first year or two is extremely successful in reducing electricity consumption, the marginal costs of further reductions may be very high.

Magnitude of Potential GHG Reduction

If residential electrical consumption were reduced by 15% each year for the next 3 years, we would avoid over that 3 year period the emission of 239 MTCDE associated with our electricity consumption, and lower total campus electrical consumption by 10% from current levels. This reduction calculation does not include the impact attitude and behavioral change may have on mobilizing other efficiency initiatives across campus (i.e. it would seem logical that once students have realized that they can reduce their electricity consumption relatively easily and have a significant impact on campus emissions, they may focus their efficiency efforts on the staggering 40% of campus electricity that the dining halls consume).

Benefits and Costs

Fixed Cost

Purchasing 20 Kill-a-Watt© Watt-Hour meters per each of 5 Commons.

100 meters @ $35 ea = $3500.00

(http://www.efi.org/products/power/p3watt.html for price quote)

equivalent to -$14.65/MTCDE avoided

Variable Cost or Benefit

There are no operating costs associated with consuming less through conservation-minded behavior like unplugging unused "power drip" appliances or buying Energy Star certified appliances. There could be operating and startup costs associated with individual Commons-based conservation projects, but these would be dwarfed by net financial gains from purchased electricity savings.

Table III.2. Conservation Projections.

Year	**0** (Current)	**1** (2002-2003)	**2** (2003-2004)	**3** (2004-2005)	**3 yr Totals**
Projected% Reduction of E consumed by Residential Buildings	100%	85%	72%	61%	39% reduction
Projected% of 2002 Consumption that Residential would represent	25%	21%	18%	15%	10% reduction
Projected kWh consumed by residential buildings	4,267,600	3,627,460	3,083,341	2,620,840	13,599,241
Projected kWh Savings	0	640,140	1,184,259	1,646,760	3,471,159
Projected Tonnes CO2 Avoided*	0	44	82	114	239
Projected Cost Purchased E for Residential Consumption	$372,778	$316,861	$269,332	$228,932	$1,187,903
Projected E Savings	$0	$55,917	$103,446	$143,846	$303,209

* 14,508 kWh of CVPS fuel mix = 1 tonne CO2

Other Costs and Benefits

Environmental. If we reduce our overall electricity consumption on campus through conservation education and behavioral change, we increase the proportion of co-generated vs. purchased electricity. Co-generated power is a "gimme", a fortunate byproduct of the College's steam-based space heating and cooling system; that heating oil will be burned and CO_2 emitted anyways. Purchased electricity also has other harmful emissions associated with it (e.g. SO_2, NO_2 and particulate matter), so if we reduce the amount of electricity purchased, we reduce all emissions associated with our electricity consumed.

Social. Decreased reliance on purchased electricity prepares us to be more self-sufficient with respect to electricity generation, paving the cultural way for the installation of our vision of a large solar or wind field to generate all campus electricity. In addition, asking students, faculty and staff to make choices about where, how and why they consume electricity (with the first step of understanding what uses electricity and how much, i.e. watt-hour meters) will encourage the development of a Middlebury College "conservation culture" which will also encourage progressive growth long into the future. Affecting real, lasting behavioral change with respect to consumption is the goal, and the necessity here.

Public Relations. If the College reduces its overall campus electricity consumption by 10-20% through a coordinated, student-led Commons-based conservation program, it would bode well for the efficacy of the Commons system, student leadership and the entire community's commitment to "walking the walk" of peak environmental performance that has been "talked" about so much.

Possible Financing Mechanisms

The only real cost is the proposed $3500 for purchasing 100 watt-hour meters. It would take only a 0.2% reduction in the first year's electricity consumption and purchased electricity annual savings to pay back this $3500.

Stakeholders

On campus

- *Carbon Neutral Representatives*. 1-2 students per Commons. Would represent Commons on the CRI/successor organization, and be responsible for managing carbon neutral projects such as *Electricity Conservation Education*.
- *Campus Sustainability Coordinator*.
- *Administration*. To fund purchase of watt-meters and receive benefits of purchased electricity savings.
- *Students*. To change consumption behavior.

Off campus

- CVPS loses some $ if we reduce demand for purchased electricity.

Examples from elsewhere

Other Colleges and Universities

SUNY-Buffalo. "Energy efficiency became a priority at SUNY-Buffalo which has provided the campus with attractive returns on investment while fulfilling a moral obligation to use energy judiciously. Furthermore, in the process of retrofitting the campus, the University at

Buffalo (UB) has educated its student body, faculty, and staff of the importance and potentials for efficiency. It has financed efficiency upgrades in a number of ways, leveraging change through a variety of capital sources including the University's own operating and capital budgets, loans from the state, and most recently by engaging the services of an energy service company that drew incentives from the local utility and helped secure financing for the remaining investment through a tax-exempt lease. When Walter Simpson became the University's first Energy Officer in 1982 the formal "Conserve UB" program was born and evolved into a program that resulted in over 300 retrofit activities. Then in the 1990s, UB entered a partnership with CES/Way International. Supported by over $4 million in incentives from Niagara Mohawk, the University engaged in a comprehensive $17+ million retrofit that has addressed heat recovery, upgrading lighting systems, the installation of high efficiency motors and drives, as well as controls and energy management systems to cut energy use while maintaining if not enhancing the quality of its buildings and facilities. While many universities have performed energy efficiency retrofits, UB stands out as a model of an integrated approach. It has at once focused on saving energy and dollars in the short term through technical measures that have created annual savings of over $9 million and $65 million in cumulative cost savings, while fostering an ethic and awareness on campus related to long-term judicious resource use. The Conserve UB approach has been a dual-pronged effort, drawing upon top-level support while shoring up the foundation with grassroots awareness of efficiency's promise and potentials." [1]

Tulane University. Tulane created an "Ecolympics" competition between residence halls. The winner of Tulane's first Ecolympics was the Willow Residence Hall. During October 2002, Willow reduced electricity use by 7.6 percent and kept 12,969 pounds of carbon dioxide out of the atmosphere. On November 14, Ben & Jerry's co-founder Jerry Greenfield traveled all the way from Vermont to visit Willow and to thank the winners for acting against global warming. Imagine what Jerry would do in-state![2]

Getting Started

1. Order 100 Kill-o-Watt watt-hour meters from http://www.efi.org/products/power/p3watt.html for $35 ea. Distribute to Commons for temporary distribution to students.
2. Get CNR's established and cooperating. Develop their portfolio/toolkit of education options.
3. Administration "challenges" Commons to reduce electricity consumption by minimum of 15%, offers a 50% incentive return on purchased electricity savings they generate.
4. Monitor electricity consumption, savings, and incentive payouts to commons.

III.3.1.b – Put CFL bulbs in all student dorm rooms

Summary data (no rebate)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
32	2.3	6	$ 963

Summary data ($3 rebate)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
30	1.1	6	$ 1,120

Almost every college student brings a desk lamp with them to school, along with an incandescent light bulb to put in it. This strategy proposes that the college provide a Compact Fluorescent Light bulb (CFL) to each student to place in his or her lamp. The CFL bulb uses ¼ of the energy of an incandescent bulb to produce the same amount of light. The bulb can be waiting in the student's dorm room and can be included in the check-in sheet. The college can then get the bulb back at the end of the year and can re-use the bulb during language school and the following school year to utilize the bulbs lifetime and to ensure proper disposal of the bulb.

Timeline

This strategy can be implemented immediately and can last as long as the college is willing to replace the bulbs that die.

Magnitude of Potential GHG Reduction

The reduction of carbon dioxide throughout the year will depend on how often the bulb is used, however, if each CFL bulb lasts its lifetime of 6,000 hours, then every single bulb will save 270 kWh of electricity**.** In other words, each bulb will save the college $24.30 over its lifetime, in addition to preventing 0.02 MTCDE from being released into the atmosphere. Thus, altogether this strategy will use 810,000 kWh less, save the college $72,900 and prevent 58 MTCDE from being released into the atmosphere.

Benefits and Costs

Fixed Cost

Http://www.bulbs.com gives the following price for the purchase of 48 or more 15-watt CFL bulbs (this gives the equivalent light of a 60-watt incandescent bulb): $5.79. Therefore, if the college were to purchase 3000 light bulbs, roughly one for each student, then the total start up cost will be $17,377.90, which includes shipping and handling. This does not include rebates or incentives. *If Efficiency Vermont were to rebate $3.00 per bulb (see below), then the start up costs will only be $8,370.00.*

Variable Cost or Benefit

The operating cost would essentially be zero, until the CFL bulb dies, which is dependent on how often the bulb is used each year. Table III.3 provides different scenarios depending on bulb usage per day that the college is running (308 days of the year, which includes language school). No matter how often the bulb is used each year, this strategy will have a benefit of $565.27/MTCDE reduced over the lifetime of the bulb, before any rebates.

Other Costs and Benefits

Environmental. The lifetime of a 15-watt CFL bulb is 6,000 hours compared to a lifetime of 2,500 hours for a 60-watt incandescent bulb. Therefore for each CFL bulb used, eight less incandescent bulbs end up in landfills. An environmental cost is that these bulbs use a small amount of mercury and therefore have to be disposed of properly and cannot be thrown away in the regular trash.

In order to ensure that the bulbs are returned so the College can utilize them for their maximum lifetime, the bulbs should be included in the check-in sheet that students receive at the beginning of the year. Therefore if they take the bulb with them, they will be charged for it. There should not be

Table III.3. Scenarios for CFL use and payback.

Based on 3,000 light bulbs	Electricity used in a year (kWh)[a]	Cost of electricity per year	MTCDE generated per year using CVPS mix[b]	Amount of money saved per year / MTCDE per yr	Payback time in years	Lifetime (years - based on 308 day year)
CFL 1 hr/day	13,860	$1,247	0.99	**$3,742/2.96**	**3.58**	**19.5**
Incandescent 1 hr/day	55,440	$4,990	3.94			
CFL 2 hr/day	27,720	$2,495	1.97	**$7,484/5.91**	**1.79**	**9.7**
Incandescent 2 hr/day	110,880	$9,979	7.88			
CFL 4 hr/day	55,440	$4,990	3.94	**$14,969/11.83**	**0.9**	**4.9**
Incandescent 4 hr/day	221,760	$19,958	15.77			
CFL 8 hr/day	110,880	$9,979	7.88	**$29,938/23.65**	**0.45**	**2.44**
Incandescent 8 hr/day	443,520	$39,917	31.54			

Calculations based on a spreadsheet designed by the Larch Company:
[a]http://www.homepower.com/files/kerrcflbulbs.xls [b]MTCDE calculated based on year 2000 data (7.11e-05 = MTCDE/kWh purchased)

a grumbling factor because the bulb will be treated like any other piece of College property – for example, a student would not think of taking the phone home with them.

Public Relations. The College can tell first-year and other students that they do not need to bring a light bulb with them because they are already provided.

Possible Financing Mechanisms

Efficiency VT (http://www.efficiencyvermont.com) rebates approximately $3 off of each bulb or ½ the purchasing price. The purchase must be pre-approved by the company, but it can be easily done over the phone (1-888-921-5990). With such a rebate the costs to the College would decrease dramatically and the payback time would be much sooner (see the details in Table I.x).

Stakeholders

On campus

Stakeholders include the students, faculty and staff (if they receive light bulbs as well), the Recycling Center (they will have to ensure the spent bulbs are managed properly –there is a company that comes to campus to pick them up).

Off campus

Stakeholders include Efficiency VT and the company we purchase the bulbs from.

Examples from elsewhere

Other Colleges and Universities

In 1990, Tufts University was the first university to sign the EPA's Green Lights Pledge, which is a promise to upgrade lighting in 90% of their floor space. Additionally, Tufts Climate Initiative (TCI) replaces people's incandescent bulbs for free.

Tulane has made an energy showcase dorm room that includes Energy Star CFL bulbs. Tulane has received a lot of publicity about the Energy Star Dorm Room and estimates that the savings if each dorm room were outfitted with Energy Star appliances and electronics will be $200,000/room. This would be great publicity for Middlebury because tours can run through the room and it would most likely get a lot of positive press from people in the community. It could also be a great example/ inspiration for students who are trying to decrease their energy consumption and need ideas.

Other Institutions

There are many examples of companies throughout the country offering rebates for people who use CFL bulbs. For example, Ace Hardware stores in the Midwest offered a six pack of Energy Star certified CFL bulbs for $0.99 during the month of October in a "Change a Light, Change the World" campaign. There is an organization in Puget Sound that offers rebates for CFL bulbs that are brought to them to be disposed of properly. A company associated with Howard University offers a buy two get one free deal. The Sacramento Municipal Utility District offered a halogen lamp trade-in for Energy Star appliances, which was met with great success. These are only a few of many examples.

Getting Started

Each commons at Middlebury has already purchased these bulbs for the first year students, they just haven't distributed them yet because they just arrived and the proper way to give them out has not been decided yet (it is too late to include it in the check-in sheet). A program to collect these bulbs at the end of the year can and should be implemented right away. Additionally, possible places that Middlebury can purchase the bulbs, which would meet the approval of Efficiency Vermont, can be investigated (try www.bulbs.com). The College can start saving money through this strategy right away, so it can be started as early as this year.

Middlebury may also want to consider signing the EPA's Green Lights Pledge. This entails signing a Memorandum of Understanding with the EPA, in which Middlebury agrees to survey facilities and within five years of signing upgrade 90% of its square footage where it is profitable and where lighting quality is maintained or improved. In return, EPA provides many programs and services, in addition to invaluable public recognition[3].

III.3.1.c – Educate students about efficient computer use

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*

14	Immediate	29	$ 1,267

Most students own a computer on campus and keep it on for most of the day, whether they are using it or not. A booklet or information session on efficient computer use should be given to the first-year students upon arrival at Middlebury. Additionally, booklets on efficient computer use should be distributed to the current student body, faculty and staff. This could also be available online and might be considered only for online use to decrease costs and save paper. The guide can include information about power save modes (screen savers do not save energy!), turning off monitors when not in use, and facts about energy efficient computer use in general (turning the computer off and on does not hurt it or shorten its life).

For example, this excerpt was taken from the University of Buffalo's Green Computing Guide[4]:

> "The EPA has estimated that providing computers with "sleep mode" reduces their energy use by 60 to 70 percent – and ultimately could save enough electricity each year to power Vermont, New Hampshire and Maine, cut electric bills $2 billion, and reduce carbon dioxide emissions by the equivalent of 5 million cars."

Timeline

This strategy could be implemented immediately.

Magnitude of Potential GHG Reduction

The magnitude is too hard to calculate because it is completely dependent on whether the students, faculty and staff follow the recommendations. A standard PC system can use electricity at a rate of 110-300 watts. Most students at this college turn on their computers in the morning, and do not turn them off until they go to sleep at night, even if they are going to be out of their room for the day. If a student kept his computer on 15 hours a day, every day for the whole school year (approximately 245 days). His computer would use approximately 735 kWh and emit 0.05 MTCDE into the atmosphere.

Now say that one student reduced his computer use to only 5 hours a day, every day for the entire school year. Now his computer only uses 245 kWh and emits only 0.02 MTCDE into the atmosphere. The savings for ONE STUDENT is therefore 0.035 MTCDE. Multiply this by the almost 2,500 student computers on campus, and you prevent 87 MTCDE from being emitted.

Benefits and Costs

Fixed Cost

Start up costs would only include the amount it costs to produce the booklets for the students, faculty, and staff. If this were only provided online then there would be no start-up costs.

Variable Cost or Benefit

If a student kept his computer on 15 hours a day for 245 days, his computer would use cost the college about $66 in electricity fees. If his computer use is reduce to 5 hours a day, the cost for the college would drop to costs $22. Accordingly, the savings for ONE STUDENT is $44. Multiply this by the almost 2,500 student computers on campus, and you get an annual savings of $110,250. Although this is a best case scenario, it illustrates that getting students to decrease their computer use is an easy, no-cost way to reduce emissions and save money.

Table I.x shows the savings and MTCDE reduced if only 1/3 of the students reduced their computer usage from 15 to 5 hours each day. This comes to an annual savings of $36,750 and reduces emissions by 29 MTCDE each year.

Other Costs and Benefits

Environmental. It may raise awareness of electricity consumption and reduce consumption in general. Less computer use will increase the computer's lifetime, thus decreasing the number of computers thrown away.

Social. Students may also become aware of computers in public labs, thus being active in making sure monitors are off and computers are in power-save mode.

Public Relations. Other colleges can refer to it to raise awareness of their student body. UB has a GREAT little pamphlet available online that emphasis's the wastefulness of computers. Also, it just generally makes us look good to prospective students, donors, foundations, etc.

Possible Financing Mechanisms

Depending on the cost of printing the booklet, there may be funding through the Environmental Council. Another option is to apply for an Environmental Grant next year.

Stakeholders

On campus

Students, faculty and staff will benefit from this education.

Off campus

Other colleges and universities can benefit from this education. (More detail?)

Examples from elsewhere

Other Colleges and Universities

University of Buffalo's Green Computing Guide:http://wings.buffalo.edu/ubgreen/documents/programs/energyconservation/guide_computing.doc

Tufts has footprints with facts about computer energy use throughout their dorms.

Colleges such as University of Michigan, Colby College, Missouri University, Bowdoin College, Old Dominion University, University of Texas, University of Oregon, St. Michaels College, St. Lawrence University, MIT, and many others have Green Computing Guides or Tips on their websites.

Getting Started

To begin with, talk to the Environmental Council and start a search for a person willing to put together a guide that can be readily available online whenever it is finished. Sarah Goodwin (x6736) is also a person to contact about putting something together. Connie Bisson, Ben Wessler, and LIS are putting together an educational campaign on Green Computing so they would be a very good place to start.

Another very important step is to make sure all public lab computers are on power save mode and that they don't use screen savers instead. There are currently 205 public computers on campus, most of which are on all day, so power save mode can save a lot of energy.

III.3.1.d – Installing "Vending Misers" on all campus vending machines

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
28	1.2	3	$ 983

There are currently 38 soda/juice machines, 15 snack machines, and 2 hot drink machines on campus. This strategy focuses solely on the 38 soda/juice machines. The vending machines on campus operate 24 hours a day, 7 days a week, 365 days a year. On average, a vending machine will consume about 427 watts, most of which is used for lighting and cooling the drinks. A Vending Miser is a small device that turns off the machine's lights and efficiently controls its temperature when the machine is not in use. As soon as a person walks in front of a motion sensor, the Vending Miser turns the machine completely on. Thus, depending on the frequency with which the machine is used, the Vending Miser drastically reduces electricity consumption, especially during vacations. Additionally, soda companies have found that Vending Misers do not impact the number of drink sales.

Timeline

Professor Helen Young is conducting a study on Vending Misers this year as part of an Campus Environmental Grant awarded by the Environmental Council. If the study shows positive results (which it already has on a preliminary basis), then Vending Misers should be installed on drink machines, especially those that are used infrequently, as soon as possible.

Magnitude of Potential GHG Reduction

According to results from the first month of Professor Young's study, the Vending Miser showed at least a 30.7% reduction in energy consumption each week. The greatest reduction was during Christmas vacation, which showed a 52% reduction in energy consumption. Thus, if each of the 38 machines had a Vending Miser, and each saved at least 30% of its energy each week, then the College would be consuming a total of 42,642 *FEWER* kWh each year. This corresponds to a savings of at least $101/year for each machine, or a total savings of at least $3,838/year. This would also reduce the college's CDE emissions by at least 3 MTCDE each year.

Benefits and Costs

Fixed Cost

An Easy-Install Vending Miser costs $162 before shipping and handling and any rebates. There are also Vending Misers that can monitor up to three machines that are banked next to each other – these cost $171. However, for simplicity, suppose each of the 38 soda/juice machines were outfitted with a Vending Miser. It would cost the college approximately $6,156 before shipping and handling and any rebates. Efficiency Vermont (see Possible Financing Mechanisms, below) provides a rebate of $45 for each Vending Miser.

Variable Cost or Benefit

There should be no operating costs associated with this strategy, assuming there are no problems installing the Vending Misers. The lifetime of these devices is five years or more. One study done by Foster-Miller, a third-party independent engineering and analysis firm serving the vending industry found that the Vending Miser has an annual savings of $45-$86 per machine in maintenance and operation costs because of decreased frequency and direct expense of component failures.

Other Costs and Benefits

Social. Signs can be posted describing the study and to raise awareness of how much electricity this college is consuming at any given time.

Public Relations. This is a great and very easy way to save a lot of energy especially during breaks. Bayview Tech., the people who make the Vending Misers, can use Middlebury College as an example for other institutions and colleges.

Possible Financing Mechanisms

Professor Young contacted Efficiency Vermont, and they provided a rebate of $45 for each Vending Miser, thus dramatically reducing the start up cost.

Stakeholders

On campus

The key on-campus stakeholders for this strategy are students, faculty, staff, and anyone visiting the college who may want a cold drink. Facilities Maintenance would most likely install and monitor the Vending Misers.

Off campus

The key off-campus stakeholders for this strategy are Efficiency Vermont, Bayview Tech., CVPS, as well as Farrell Distributors and any other vending companies that stock these machines.

Examples from elsewhere

Other Colleges and Universities

Tufts University did a trial run with a Vending Miser and found that the vending machine's energy consumption was cut in half. They predicted a payback time of less than a year, and are now installing 75 Vending Misers throughout their campus.

Bowdoin College also installed Vending Misers in first-year dorms last April. They expect decreases in energy consumption of around 50%.

Other Institutions

Several governments including the states Washington and Utah are pushing employees to buy Vending Misers for their cold drink machines.

The National Renewable Energy Laboratory has installed 12 Vending Misers. On a pilot study done with two Misers, they found a reduction of 35%.

Getting Started

Contact Helen Young about her study on the Vending Misers and Kelly Giard (Dining Services) about the frequency that each vending machine is used on campus (we may want to consider getting rid of vending machines that are not used very often for added savings). Additionally, vending machines that are located close enough to 'bank' together on one Vending Miser should be identified.

III.3.2 Reduce carbon emissions associated with sources of College electricity

Summary of Strategies

a. College's Role in Vermont Electricity Policy

b. Solar Paneling

III.3.2.a – College's Role in Vermont Electricity Policy

Summary data (5% fossil fuel reduction)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
5	Immediate	27	$ 3,186

Summary data (10% fossil fuel reduction)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
5	Immediate	81	$ 1,062

Summary data (15% fossil fuel reduction)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
5	Immediate	81	$ 1,062

As a progressive academic institution with national recognition, and as a formidable economic force in the state of Vermont, Middlebury College has an opportunity and an obligation to advocate sustainable and renewable energy options as Vermont re-evaluates its electricity generation portfolio with the planned 2012 decommissioning of the Vermont Yankee nuclear power plant. The 13th largest employer in the state, direct and indirect annual economic activity from Middlebury College supports 2,200 jobs and $59.9 million in earnings for Addison county workers, in addition to generating local direct and indirect business revenues of approximately $12 million annually. The significance of Middlebury's economic, social and public relations contributions to the state of Vermont grant us considerable leverage in affecting positive change in the state.[57]

Vermont Yankee nuclear power currently supplies 41% of the college's purchased electricity needs, and 51% (1999) of the state's electricity needs. Several possible electricity generating replacement plants have been proposed for when Vermont Yankee is decommissioned in 2012. This includes a 1000MW coal power plant, which would certainly be an environmental loss for a purportedly "green" state.

We propose that President McCardell and the Middlebury College community promote a replacement electricity solution that is cleaner – if not carbon neutral. Wind or solar power would clearly be best. Natural gas would be cleaner than oil or coal, but its combustion still emits CDE. More hydroelectric power, while carbon neutral, is not the preferred solution, as most of our hydro is outsourced to HydroQuebec who is currently seeking opportunities to expand, and who has come under fire historically for the environmental impact of its facilities and the displacement of indigenous peoples.

A consortium of New England Governors and Canadian provincial ministers recently challenged regional universities and colleges to aggressively address and mitigate their global warming footprint – let's go back to them and say, "We know what we – us as a school and us as a state – have to do. How can we help you and how can you help us get there?"

Timeline

Vermont Yankee nuclear power plant is schedule to be decommissioned in 2012, with an option to extend its license another 5-10 years.

Magnitude of Potential GHG Reduction

The magnitude is difficult to quantify until we know for sure how Vermont is planning to replace the 40% share of its electricity supplied by Vermont Yankee.

Based on the College's consumption of 0.323% of Vermont's total electricity consumption, and DOE observed reduction rates … If Middlebury College advocates a total VT generation portfolio comprised of 5%, 15%, or 25% renewably-generated electricity rates (RPS), projected MTCDE reductions matched to the College's 0.323% of total state electricity are shown in Table III.9.

See Section III.3.2.a, Switching Vermont Electricity.

Table III.9. MTCDE Reductions from State Advocacy.

2000 Fuel Mix of Electricity Purchased by Middlebury College			
Fuel Type	Percent Mix	kWh Produced	Net MTCDE Emitted
# 6 Oil	2.70%	537,712	537
Nuclear	41.10%	8,185,170	878

Hydro	34.40%	6,850,848	0
Wood	21.80%	4,341,526	0

Middlebury College CDE Emission if Vermont Restructured in 2000			
Fossil Fuel Type	5% Fossil Fuel Reduction (MTCDE)	15% Fossil Fuel Reduction (MTCDE)	25% Fossil Fuel Reduction (MTCDE)
# 6 Oil	510	456	403
Total Emissions Reduction	-27	-81	-134
$/ Tonne	+3,186	+1,062	+642

Benefits and Costs

Fixed Cost

None.

Variable Cost or Benefit

None.

Benefits

A summary of operating benefits is provided in Table III.10 below.

Table III.10. Cost Analysis.

Cost Analysis of Vermont Electricity Restructuring For Middlebury College	
Average Cost Reduction (kWh) of Industrial Electricity in Deregulated States (1996-2000)	-4.80%
Cost (kWh) Paid by College (2000)	$0.09
kWh Consumed by College (2000)	19,915,255
$ Spent by College on Purchased Electricity (2000)	$1,792,372
$ Spent by College on Purchased Electricity If Vermont was Deregulated	$1,706,338
$ Saved by College if Vermont Deregulated	$86,035

Other Costs and Benefits

Environmental. Avoidance of large single-source increase in CO_2 emitted to provide statewide electricity.

Social. Will reinforce that we – Middlebury College – have a culture that supports environmental health and human need.

Public Relations. Establishes College's public commitment to supporting "green" energy initiatives and decisions on campus and in our state.

Possible Financing Mechanisms

N/A.

Stakeholders

On campus

- President McCardell.
- External Affairs/Public Relations.
- Entire Middlebury College community.

Off campus

- State legislators
- Governor
- Utilities
- Energy consultants
- Voters/citizens
- Whole state of Vermont.

Getting Started

Take a closer look at what options are feasible for the state. Establish relationships with state officials and agencies, offer resources (research, professors, links with other universities). Begin a dialogue by starting a Middlebury College Consortium on Vermont State Energy Policy, which would incorporate the voices and knowledge of incredible academic resources the College has access to on and off-campus.

III.3.2.b – Solar Paneling

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
25	None	1	$ (46)

Renewable energy is the only way by which Middlebury can obtain permanent carbon neutrality. Because of the still developing nature of these technologies, combined with Vermont's climate, we suggest a three-phased approach. First, install a small set of solar panels at a highly visible location on campus to serve as a symbol of the college's commitment to carbon reduction and as an educational tool. Next, as funds from other energy saving measures accumulate, gradually add PV panels to other south facing buildings including: Stewart, Voter, Munroe, Forester, Carr, Warner, Allen, and Sunderland. Finally, as soon as technology permits, the college must invest in deriving a significant percentage of its electricity from campus controlled solar technologies, perhaps something along the lines of a solar field near the CFA. As the first of these strategies is already being examined under an Environmental grant given to Skye Bourden and Baker Lloyd and the final step is a long time away, this report will focus on gradually installing solar panels on specific campus buildings.

Timeline

While it is important for the college to support solar technology as it develops, the ratio of carbon reduction to cost is low for on campus solar options as compared to other carbon reducing strategies. Wide scale solar paneling should not be implemented until strategies with a higher magnitude of reduction have been pursued and enough savings from these strategies have accumulated to partially finance the project. This is therefore a long-term project whose impact will only increase as technology becomes better and less expensive.

Magnitude of Potential GHG Reduction

A single 120-watt PV panel would produce around 150 kilo Watt-hours of energy,[58] which, by replacing purchased electricity, would reduce carbon emissions by approximately 0.01 MTCDE. It is hard to guess the number of panels that a roof could hold without a professional opinion, however a rough estimate of the potential yearly kWh production for each building product is given in Table III.11. If Middlebury were to install solar paneling on the eight suggested buildings it would lead to a 1.3 MTCDE reduction each year. Over a lifetime of perhaps 75 years this would lead to a total 97.5 MTCDE reduction.

Benefits and Costs

Fixed Cost

The initial startup cost for solar paneling would be significant. Middlebury could purchase a solar paneling system, which includes other necessary equipment, consultation, installation, and an additional warranty from Vermont Solar Engineering for around $900 a panel[59]. This would mean that the average cost for each building project would be $14,000 and the total strategy cost would be $112,500. There is however a range of prices, similar solar panels can be purchased from BP for $500[60]. This with an estimated installation cost of $1000 and $2000 set aside for other equipment would be closer to a total cost of $88,000 for all 8 proposed buildings.

Variable Cost or Benefit

Operating costs would be minimal, as solar panels require little care and most repairs would be covered by the warranty. In addition the panels once all installed would save the college $1,700 in electricity cost a year.

Other Costs and Benefits

Environmental. Electricity derived from solar energy releases no pollutants whatsoever, it does not deplete any non-renewable resource, and it has a

Table III.11. kWh Production by PV

Building	# of PVs	kWh generated
Stewart	25	.26
Forester	20	.21
Munroe	20	.21
Voter	20	.21
Warner	15	.15
Carr	5	.05
Sunderland	10	.11
Allen	10	.11

relatively minor ecological footprint. It is the most basic, stable, and 'green' energy. The only environmental cost associated would be the energy, materials, and waste connected with the upstream production of the actual technology.

Social. Solar energy has several non-environmental benefits. It would decrease dependence on fossil fuels, easing the connected political and economic issues that are currently so prevalent. It would make the campus more self-sufficient leading to more control over electricity choices and creating a more stable electrical supply. Finally, over the long, long term it is less expensive than continuously purchasing energy. The social cost of disturbance during installation would be minimal if timed right as installing solar panels usually takes less than 2 days[61].

Public Relations. Solar panels are one of the most recognized indications of 'greenness'. By installing solar panels the college would create a strong image of its commitment to being an environmental leader. This would be particularly valuable as panels would be recognizable to almost everyone, even those not directly familiar with college environmental issues.

Possible Financing Mechanisms

All funding for this project should come from the savings of other carbon reducing electricity strategies. In addition the college can look for outside financial help. Efficiency Vermont might be willing to partially fund the project while the Vermont government offers incentives in the form of a sales tax exemption. Some schools have been able to receive grants from the DOE Million Solar roof initiative and other similar government programs.

Stakeholders

On campus

Facilities Management, specifically whoever was put in charge of monitoring the panels. The Board of Trustee who would approve the financing of the project. Admissions and other publication groups who would want to write about the project. Students, faculty, and staff who would be in the buildings or who would be using electricity generated by the panels.

Off campus

Whoever we buy the solar panels from (Vermont Solar Engineering, Solar Works Inc., BP) and whoever we hire to install and maintain them, if different from the supplier.

Examples from elsewhere

Other Colleges and Universities

The University of Vermont with the help of Burlington's Electrical Department recently installed 48 120-Watt PV panels on top of their on campus heating plant which produce 6,935 kilowatt hours of energy a year. They are also maintaining a website about the project at http://www.uvm.edu/~solar/?Page=default.html which precisely details energy outputs from the panels.

Tufts University, a leader in college-based climate change initiatives, currently has solar panels on two residential houses and is working on integrating solar energy into the colleges building maintenance policy.

Similarly *Connecticut College* has installed PV cells on a new dorm.

The University of Central Florida has a Solar Energy center that is one of the largest, most active renewable energy research, training, testing, and certification institutions in the US as well as a great resource (http://www.fsec.ucf.edu/about/index.htm).

Other Institutions

All across the U.S. and Vermont businesses are finding it economically and environmentally logical to switch to partial solar energy.

Getting Started

The college should contact Solar Works, Inc. or some other outside consulting group to more thoroughly analyze the best place on campus to install solar paneling and how many panels can actually be installed in each location. They should also become involved in the company's Solar on Schools program.

III.3.3. Offset existing carbon emissions by supporting renewable electricity generation

Summary of Strategy

Summary data (Native Energy)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
50	None	36,000	$ (8)

Summary data (ReGen)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
53	None	36,000	$ (47)

Summary data (Addison County Schools)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
52	None	36,000	$ (35)

Energy offsets, also known as Green Tags, fund renewable energy projects that reduce the amount of fossil fuels burned to meet the demands of electricity grids across the country. They offer a unique solution to regulation and accessibility problems by making the environmental benefits of renewable energy universally available and also often have significant social benefits. By purchasing energy offsets Middlebury College would not only receive credit for the carbon difference between solar, wind, and biomass relative to fossil fuels but would also be encouraging the renewable industry through a form of subsidies. We emphasize here that there is an important conceptual difference between "new" generation capacity vs. tags on existing capacity: the carbon reduction associated with a new source is much easier to verify.

Some potential sources of offsets that Middlebury should examine further are:

Native Energy: Native Energy is a Vermont based company devoted to reducing atmospheric carbon dioxide by establishing 150 wind turbines over the next five years. The company's current projects include working with the Rosebud Sioux Tribe to build the first large scale Native American owned wind farm and the establishment of a biogas anaerobic manure digester at Knoxland Farm in Bradford, Vermont. As they have dealt with large businesses in the past they could probably meet all off Middlebury's offset demands. For more information go to www.NativeEngergy.com.

ReGen: ReGen is one of six companies certified by Green-e to give Green Tags. It is unique in that it focuses entirely on the New England region, working with Sun Power Electrics to generate renewable energy in the Northeast. Currently most of the energy purchased by ReGen (99%) is from landfill biomass and is integrated into the Massachusetts power grid. For more information go to www.sunpower.org.

Addison County Schools: Addison County Schools are in the process of examining ways to improve their energy efficiency and are looking into the possibility of renewable energy. Middlebury College could become involved in this process, offering to partially fund the project in exchange for the temporary rights to the resulting CO_2 emissions reduction. In addition to serving as an efficient offset, the creation of such a relationship would strengthen the college's ties with the surrounding community.

Additional offset options to consider include: Community Energy at http://www.newwindenergy.com/, Sterling Planet at http://www.sterlingplanet.com/sp/index.jsp, Bonneville Environmental Foundation at https://www.greentagsusa.org/GreenTags/index.cfm, Renewable Energy at http://www.renewablechoice.com/, Auilia at http://www.theenergyteam.com/, 3 Phases Energy Service http://www.3phases.com/.

Timeline

The college can start buying offsets immediately. One option would be to achieve Carbon Neutrality as soon as next year by offsetting total carbon emissions. This would buy the college time to implement many other of the strategies suggested in this report. Another option would be to purchase energy offsets when sufficient funds from other energy saving measures have accumulated, creating a nice closed loop. This could probably start to happen within the next 5 years. The best solution is probably found somewhere in between these two extremes. We suggest immediately buying a small number of offsets to establish a relationship with the company and figure out the actual process. Then, when Middlebury is ready to achieve carbon neutrality through a combination of strategies, offsetting the remaining emissions will be easily implemented.

Magnitude of Potential GHG Reduction

There are few limits on the number of offsets Middlebury can purchase. While individual companies have a set number of offsets they can sell at any one time, this number is above Middlebury's current reduction need, especially if it chooses to diversify. The magnitude of reduction will therefore be determined by Middlebury's level of carbon emissions and the decision as to what percentage of offsets should be focused on renewable energies.

Benefits and Costs

Fixed Cost

Start up costs would be essentially buying the offsets. From Native Energy we can purchase one tonne of CDE for $10, with discounts if we purchase more than 100 tonnes. ReGen sells 2,000 kWh for $72, which roughly translates into $47 per ton. The cost of working with Addison County will take significant calculations and will probably be at the higher end of the offset range, $20 - $50 per ton.

Variable Cost or Benefit

Once an offset is purchased the offset company manages any issues related to it, including monitoring and insuring the full magnitude of the offset, whose CDE reduction may not be realized for many years. However, the college must establish a way to manage its offset portfolio. This would entail changing the job description of someone on campus, perhaps Connie Bisson, to take responsibility for this. There is also the possibility of outside consulting such as that offered by Native Energy. In the case of arrangements with Addison County, a greater share of the monitoring and insurance responsibility would fall on the college.

Other Costs and Benefits

Environmental. Because the college is enabling a renewable energy source to be established, other environmental benefits associated with such an action occur, including reduced hydrocarbon pollution, less resource depletion, and reduced habitat change. Also, because these projects are usually in areas ideal to the particular technology, offsets maximize the efficiency of the product, creating the most CDE-free energy for the lowest cost. One caution with respect to buying electrical offsets is that if the money is just going to the purchase of already generated electricity or the maintenance of the source, it is arguable that that clean electricity would have been created even without your contribution. The college should therefore emphasize those companies that focus exclusively on adding new renewable energy projects, such as Native Energy.

Social. Many social benefits accompany offsets. Offsets with Native Energy provide independent and sustainable energy sources to groups like tribes or small farmers who would otherwise not be able to afford them, as well as supporting Native Energy itself, a Vermont-based company. Similarly, support for Addison County schools will enable local schools to implement the desired technology without having to make major budget sacrifices in other areas.

Public Relations. Offsets will allow Middlebury College to declare itself "Carbon Neutral", something no other college has yet done. Also purchasing offsets at the local scale such as is possible through Native Energy and the Addison County School project will present the college as investing in the surrounding region.

Possible Financing Mechanisms

In the future most of the money for offsets will come from other savings-generating CDE reduction strategies. Immediately, while we wait for these projects to be started, the college would have to purchase offsets out of another budget. The cost of offsets would be low. One alternative if the college does not want to divert funds is to take a campus wide vote seeing if students, faculty, and staff are willing to pay for carbon neutrality themselves and if successful charge everyone ten or so dollars. The other alternative is to ask Alumni to help in making Middlebury Carbon neutral.

Stakeholders

On campus

Mostly the administration would have to deal with the offsets, by establishing a budget line and appointing someone to interact with the companies and manage the college's offset portfolio. However, the college could encourage students, faculty, and staff to become involved by also purchasing offsets for their personal CDE-emitting activities. If the college focuses on Addison Country Schools, for example, more energy and time would be required in order to specify the specific nature of the relationship and work through many of the calculations.

Another possibility is to work with Native Energy to promote the purchase of renwable offsets. According to Tom Stoddard, Vice President and General Counsel, Native Energy has proposed to other colleges (and received considerable interest) that the colleges sell individual 'WindBuildersSM' offsets, and use the Native Energy commissions to help fund the school's acquisition of offsets. Interested students could offer WindBuildersSM to parents and friends, or the college could implement a coordinated outreach to alumni. Accorindg to Tom, "It's a great opportunity to spread the word about what Middlebury College is doing, and to teach a broader group about global warming and renewable energy. Our standard commission is 15% of revenues, or we could donate ~2 tons of CO2 offsets to the college for each 10 tons sold through the outreach effort. The result is that by funding its acquisition, e.g., of 10,000 tons of offsets this way, Middlebury College would actually be helping reduce CO2 emissions by a total of 50,000 tons."

Off campus

The company /organization providing the offsets, as discussed above.

Examples from elsewhere

Other Colleges and Universities

Lewis and Clark College in Portland, Oregon is one of the few colleges to realize the potential of offsets and to act on them. As of September 2002 they became the first U.S. college to meet Kyoto targets through a student-based initiative that purchases $1,700 in offsets.

Other Institutions

Native Energy: Ben & Jerry's (One Sweet Whirled campaign), Coop America, Timberland, Vermont Business for Social Responsibility, UTNE reader, EBX, Indigo Girls, Gravel and Shea Attorneys at Law, Natural Resource Defense Council, and Northshire Bookstore.

ReGen: Shaws Supermarket, Appalachian Mountain Club, and Union of Concerned Scientists.

Getting Started

The first step will be to let the offset companies/institutions know that Middlebury is interested in purchasing offsets from them as most companies offer pre-purchasing advice and analysis. Native Energy can be contacted by calling 800-924-8616 or by emailing them at business@nativeenergy.com. ReGen can be contacted by calling 1-800-689-7957. For Addison County Schools Maggie Ryan, wife of Pete Ryan from the Geology department and a member of the Weybridge School Board, should be contacted.

III.4 Future Considerations

III.4.1 – Vermont Electricity Restructuring

Electricity deregulation (or more correctly known as restructuring) allows electricity consumers to choose their electricity supplier, while the transmission and distribution of power remains the electric company's responsibility.[18] The purpose of deregulation is to foster competition among electricity suppliers with the medium and long-term goal of combating the high prices maintained by government-sanctioned regional monopolies.[19]

Of the 22 states (including the District of Columbia) that are currently retail restructured, on average they have experienced a 13.67% reduction in residential rates, a 13% reduction in commercial rates and a 4.8% reduction in industrial rates from 1996-2001.[20] In 1999 alone, such a rate reduction would have saved Vermont residents $33.2 million, Vermont business $26.3 million and Vermont industries $5.6 million. Despite such figures, the Vermont electricity industry remains regulated. Middlebury College could help form a consortium of Vermont colleges, universities and businesses (in addition to grassroots involvement), which advocates the quick, but prudent restructuring of Vermont's electricity industry.

The Vermont Legislator has already taken steps—albeit few—to begin the electricity restructuring process. The restructuring timeline for Vermont (which can also be viewed at the following URL: http://www.deregulation.com/electric.html - Vermont) is as follows:

- (12/96) The Vermont Public Service Board (PSB) released a plan to restructure the electric power industry in Vermont — it called for retail competition by 1998, functional unbundling, and permitted recovery of stranded costs. The Vermont Department of Public Service (DPS) plan requires legislative action to implement it. The complete Report and Order entered on 12/30/96 can be viewed.
- (4/97) The Vermont Senate passed a bill that was based on a DPS plan that would have permitted retail choice by 1998 — the bill stalled in the Vermont House.
- (8/97) The House formed a committee to study restructuring issues.
- (10/97) The House Electric Utility Regulation Reform Committee voted not to propose any retail wheeling legislation in 1998 but to draft a version of its restructuring bill for 1999.
- (1998) Several restructuring bills were considered but no action was taken on any of them.
- (8/98) A task force was created to report on restructuring with a report due in 12/98.
- (12/98) The Vermont Governor's Working Group on Vermont's Electricity Future created a report which contained a restructuring plan suggesting three major Vermont utilities

merge and that contract costs with Hydro Quebec be paid down with Vermont-backed loans.

- (3/99) Central Vermont Public Service Corp. and Green Mountain Power Corp. filed a joint restructuring plan with the PSB of Vermont — the plan proposed consolidating the two companies into one distribution company and both companies would sell their generating assets.
- (7/2002) Senate Bill 138 (Act 145) took effect, which allows farms to produce electricity using renewable energy sources, and sell the surplus energy to electric companies.

Timeline

Between 2003-2012.

Magnitude of Potential GHG Reduction

In 1999, 7.2 % (or 43,349,000,000 kWh) of the electricity distributed in Vermont, was generated by fossil fuels.[21] This electricity generation produced approximately 38,094,984 MTCDE. If Vermont could reduce its use of fossil fuels to generate electricity by 5%, it would decrease its emissions by 1,904,748 MTCDE per year; if Vermont reduced its use of fossil fuels by 15%, it would decrease its emissions by 5,714,246 MTCDE per year; and if Vermont reduced its use of fossil fuels by 25%, it could would reduce its emissions by 9,523,744 MTCDE per year.

These fossil fuel reduction goals are not outrageous. In fact, many other deregulated states are making or have already made similar reductions in fossil fuel electricity generation. Notably, California plans to produce 20% of its electricity using renewables by 2017; Connecticut is aiming for 13% by 2009; New Jersey's objective is 6.5% by 2012; and Maine has already begun producing 30% of its electricity using renewables starting in the year 2000.[22]

Furthermore, since 1999 (when the Pennsylvanian electricity industry was deregulated), renewable energy products have gained 12% of the electricity market (note: in 1998, 0% of the electricity generated in PA came from renewable sources).[23] If extrapolated, this increase in electricity generated by renewables estimates that in approximately 50 years, 100% of Pennsylvania's electricity generation will come from renewable energies. In applying this figure to the Vermont electricity industry (which in 1999, generated approximately 63% of its electricity from non-renewable sources)[24], one could estimate that had Vermont deregulated in 1999, it would have taken approximately 32 years for Vermont to begin producing 100% of its electricity from renewable energy sources. Consequently, reducing Vermont's fossil fuel use by 5% or even 10% through deregulation is a plausible target. See Table III.7 below for more details.

Benefits and Costs

Startup Costs

There will be no start up costs for Middlebury College. It will however, require time. The College consequently, may delegate some of the workload to student organizations—e.g. Environmental Quality and Middlebury Initiative for Sustainable Development (among others). The College may also want to delegate part of the workload to college councils—e.g. the Environmental Council and Student Government.

Operating Costs

There will be no operating costs for Middlebury College.

TABLE A: [25] 1999 % of Electricity Generated by Fuel Types in VT	
#6 Oil	0.40%
Natural Gas	0.30%
Nuclear	71.10%
Hydro	20.90%
Other	7.20%

TABLE B: [26] 1999 Electricity Production in VT (kilowatt hours)	
#6 Oil	25,058,000,000
Natural Gas	18,291,000,000
Nuclear	4,059,107,000,000
Hydro	1,195,696,000,000
Other	410,966,000,000

TABLE C: 1999 CDE Emissions due to Electricity Production in VT (tonnes)	
#6 Oil	25,037,954
Natural Gas	13,057,030
Nuclear	435,785,727
Hydro	0
Other	-

TABLE D: CDE Emissions of Vermont If It Restructured in 1999 (tonnes)	
5% Reduction of Fossil Fuels/ CDE	
# 6 Oil	24,412,005
Natural Gas	12,730,605
Reduced Emissions	-952,374
15% Reduction of Fossil Fuels/ CDE	
#6 Oil (-7.5%)	23,160,107
Natural Gas (-7.5%)	12,077,753
Reduced Emissions	-2,857,123
25% Reduction of Fossil Fuels/ CDE	
#6 Oil (-12.5%)	21,908,210
Natural Gas (-12.5%)	11,424,902
Reduced Emissions	-4,761,872

Table A and B are figures from the Energy Information Administration—which is a part of the U.S. Department of Energy. Table C was calculated using the same conversion factors that were used in strategy III.3.2.b – Switch Electricity Providers. To calculate the values in table D, the MTCDE generated from # 6 oil, and the MTCDE generated from natural gas were each multiplied 2.5%, to calculate a 5% reduction in fossil fuel use in Vermont. To calculate a 15% reduction in fossil fuel use, the MTCDE generated from # 6 oil, and the MTCDE generated from natural gas were each multiplied 7.5%. Lastly, to calculate a 25% reduction, in fossil fuel use, the MTCDE generated from natural gas and the MTCDE generated from #6 oil were each multiplied by 12.5%.

Benefits

Restructuring will not only protect the environment, but it will also save residents, businesses and industries money—money which may be used to purchase offsets, furthering the state's commitment to the environment. In 1999, Vermont residents spent $243 million, Vermont businesses spent $202 million and Vermont industries spent $117 million on electricity. The average cost per kilowatt-hour was 12.17 cents for Vermont residents; 10.67 cents for Vermont businesses; and 7.35 cents for Vermont industries. If Vermont had restructured the electricity industry in 1999, however, Vermont residents would have only paid 10.5 cents per kilowatt-hour and would have spent only $209.8 million—constituting a savings of approximately $33.2 million. Similarly, Vermont businesses would have only paid 9.28 cents per kilowatt-hour and would have only spent $175.7 million—constituting a savings of roughly $26.3 million. Vermont industries would have only paid 7 cents per kilowatt-hour and would have only spent $111.4 million–constituting a savings of nearly $5.62 million. All in all, the restructuring of Vermont's electricity industry in 1999 could have saved Vermonters $65.12 million in electricity bills (see Table III.8).

Table III.8. Projections of Cost Savings with Electricity Restructuring.

TABLE E:[27] Average Cost Reduction of Electricity in Deregulated States (1996-2001)	
Residential	-13.67%
Commercial	-13.00%
Industrial	-4.80%

TABLE F: Revenue from Electricity Sales in VT (1999)	
Residential	$243 million
Commercial	$202 million
Industrial	$117 million

TABLE G: Average Electricity Cost in VT (1999)	
Residential	12.17 cents/kWh
Commercial	10.67 cents/kwh
Industrial	7.35 cents/kWh

If VT was restructured in 1999:

TABLE H: Average Cost of Electricity:	
Residential	10.5 cents/kWh
Commercial	9.28 cents/kWh
Industrial	7 cents/kWh

TABLE I: Average Savings in Vermont	
Residential	$33.2 million
Commercial	$26.3 million
Industrial	$5.62 million
Total	$65.12 million

The data in table E were calculated by the National Renewable Energy Laboratory (a DOE national laboratory), in collaboration with the National Conference of State Legislatures. The data located in tables F and G were collected by the Energy Information Administration—a branch of the U.S. Department of Energy. To estimate the reduction in cost per kilowatt hour if Vermont had deregulated in 1999 (table H), the % reductions in table 5 was multiplied by the average cost per kilowatt hour in table G. To estimate the savings if Vermont had deregulated in 1999 (i.e. table I), the % reductions in table E were multiplied by the revenue from electricity sales in Vermont in table F.

Other Costs and Benefits

Social. Electricity restructuring may discourage energy conservation because it will lower electricity prices, which will most likely result in increased consumption.[28] Despite this drawback, electricity restructuring has many social benefits. Notably, it may create a competitive market between producers, which in turn, lowers cost to consumers by stimulating innovation and creating incentives to reduce overhead (usually by becoming increasingly efficient). Diversifying the electricity mix with renewable energy also helps stabilize electricity prices because it decreases dependency on the volatile fossil fuel market.

Environmental. Electricity restructuring will also help improve air quality, encourage efficiency and because the reduction of company overhead is most often easily achieved by reducing fossil fuel dependency and increasing investment in renewable technologies (note: on average, the national electricity industry produces: 70% of the U.S.'s sulfur dioxide emissions, 30 % of the U.S.'s carbon dioxide emissions, 30% of the U.S.'s nitrogen dioxide emissions and 18 % of the U.S.'s mercury emissions, not including particulate matter).[29]

Public Relations. Advocating electricity restructuring will not only reduce CDE emissions and improve air quality, but also save Vermont residents money as well as create higher paying jobs in the state.

Possible Financing Mechanisms

None needed.

Stakeholders

On campus

Middlebury College

Off campus

1. Vermont Residents
2. Vermont Businesses
3. Vermont Industries
4. Vermont Utilities
5. Vermont Legislators

Examples from elsewhere

Other Colleges and Universities

University at Buffalo—in their Environmental Stewardship and Green Campus report—does not support the restructuring of the electricity industry. Some of the information in their report however, is false (e.g. that California's energy crisis was the result of deregulation), and the report itself did not discuss any of the other 22 currently retailed restructured states (click to read the report).

Tufts University however, does support electricity restructuring, as stated in the Tufts Climate Initiative—which is a member of Mass Energy's Clean Electricity Aggregation Project. The project seeks to establish a green power product, which would give Massachusetts's customers the option to buy electricity from renewable power. The project is headed by Massachusetts Energy and funded by a grant from MTC.[30]

Other Institutions:

(21 states and the District of Columbia are currently retail restructured)[31]

1. Arizona
2. Arkansas
3. California
4. Connecticut
5. Delaware
6. District of Columbia
7. Illinois
8. Maine
9. Maryland
10. Massachusetts
11. Montana
12. Nevada
13. New Hampshire
14. New Jersey
15. New Mexico
16. Ohio
17. Oklahoma
18. Oregon
19. Pennsylvania
20. Rhode Island
21. Texas
22. Virginia.

Much of the U.S. public has been lead to believe that deregulation caused the California Energy Crisis. In reality, the crisis occurred because of corporate price gouging and inefficacious legislation (among other factors).[32] Only recently have these corporations been held accountable. Notably on November 12, 2002, the Williams Companies—which is one of the nation's biggest suppliers of electricity and natural gas—agreed to pay more than $400 million to settle accusations that it helped drive up prices and overcharged customers during the state's electric power crisis.[33] Additionally, on December 13, 2002, the judge of the Federal Energy Regulatory Commission (Bruce L. Birchman), ruled that energy companies overcharged California about $1.8 billion during the crisis due to price gouging.[34]

Despite this one outlier, states that have undergone electricity restructuring have been largely prosperous—e.g. Pennsylvania. Since 1999 (when it was restructured), Pennsylvania has seen residential rates fall 20%, commercial rates fall 16% and industrial rates fall 17%.[35] Additionally between 1999 and 2000, 80,000 PA customers have switched to renewable energy and cleaner energy products, and $75 million have been raised (through RPSs) to support clean energy initiatives.[36] Renewable Energy Portfolio Standards (or RPS) require that over time an increasing amount of the state's electricity be generated by renewables. Money for RPSs is often raised by imposing small charges for transmission or distribution (e.g. in PA the charge is $0.0001/kWh).[37] The Department of Energy Interlaboratory Working Group (IWG)—consisting of the five national energy research labs—found that, when combined with energy efficiency programs, an RPS of 7.5% by 2010 would save consumers over $65 billion per year by 2020.[38]

Getting Started

1. Build solidarity and a working relationship with other colleges, businesses and NGOs
   - Colleges: UVM Environmental Council (Gloria Thompson)
     email: **Environmental.Council@uvm.edu**
   - Businesses: Native Energy: http://www.nativeenergy.com/
   - NGOs: Clean Air Cool Planet: http://www.cleanair-coolplanet.org/

2. Contact your local Vermont legislator representative, who may be found at the following URL: http://www.rutlandherald.com/legislature/guide/senbycounty.html
   - Advocate restructuring of the Vermont's electricity industry

3. Educate and encourage students to do the same.

III.4.2 – Switch Electricity Providers under Deregulation

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
4	0.0	61	$ 4,375

Vermont Yankee Nuclear Power Plant is an electricity utility, located in Vernon, VT, which provides approximately 51% (in 1999) of Vermont's electricity, and is scheduled to be decommissioned in 2012.[5] The Vermont Public Service Department (PSD) determined that Vermont Yankee's operating costs would increase by $22 million for each additional year that it operates after its contracted life (note: the PSD also concluded that it would cost the VT taxpayers more to decommission the plant earlier than the contracted date).[6] On July 31, 2002, Entergy—an out-of-state energy corporation that now owns ten nuclear power plants across the nation—bought Vermont Yankee, making its decommissioning and replacement power uncertain.[7]

This uncertainty brings into question whether, in a deregulated Vermont, Middlebury College should continue to be serviced by Central Vermont Public Service (CVPS), which is Middlebury College's existing electricity provider. CVPS currently buys 41.1% of its electricity from Vermont Yankee. If a coal-fired, oil-fired, or natural gas-fired electricity generating plant replaced Vermont Yankee, not only would Middlebury College's carbon dioxide footprint increase dramatically, but the amount of capital it spends on purchased electricity would increase substantially as well.

Under current state law, as discussed in the previous sub-section, Vermont has created distinct service territories, which gives CVPS monopoly status for energy and power in central Vermont. After deregulation, Middlebury College should consider 3 courses of action: 1) it should reevaluate its CDE footprint from CVPS purchased electricity in 6 to 8 months; 2) it should, subsequently, consider switching electricity providers from CVPS to Green Mountain Power (note: Middlebury College should further investigate the regulatory implications/possibility of switching providers); and 3) it should advocate Vermont Yankee's succession by a plant which generates electricity using renewable fuels—in which case Middlebury College should remain with CVPS.

Green Mountain Power (GMP), more specifically, is an electricity supplier that relies on Vermont Yankee for 30.8% of its electricity (as opposed to CVPS's 41.1%).[8] GMP is also the electric utility noted for being:

- 1st in the nation for low sulfur dioxide emissions
- 2nd in the nation for low nitrogen oxide emissions
- 9th in the nation for the percentage of renewable energy in the total energy mix

A comparison of the GMP and CVPS fuel mixes can be found in Table III.4.

Table III.4. Fuel Mix for GMP and CVPS.[a]

Green Mountain Power [9]	
Fuel	**Percentage (%)**
Renewables	41.2
Hydro	37.4
Wood	3.3
Wind	0.5
Nuclear	30.8
Natural Gas	2.1
#6 Oil	2
Market Purchases[b]	23.9

Central Vermont Public Service [10]	
Fuel	**Percentage (%)**
Renewables	56.2
Hydro	34.4
Wood	21.8
Nuclear	41.1
Coal	0
#6 Oil	2.7

[a] These fuel mixes can and do change from year to year. [b] Market Purchases constitute surplus power bought and sold on the New England Electricity Grid. As a result, GMP does not know the exact fuel mix. By the end of this year however, GMP plans to be put on a system, which will allow it to track the % of each fuel source that comprises their market purchases.[11] The calculations (below) assumed 100% of these market purchases were generated by renewable sources.

Timeline

Long term—i.e. between 2003-2012.

Magnitude of Potential GHG Reduction

If Middlebury College is able to switch to GMP within the next year (assuming choosing an electricity provider is permitted by law), Middlebury will decrease its CDE footprint by 61 MTCDE per year. When the Vermont Yankee Nuclear Power Plant is decommissioned in 2012, however, this reduction in Middlebury College's CDE footprint becomes uncertain, as Vermont Yankee could be replaced by four possible types of electricity-generating plants: 1. coal-fired; 2. # 6 oil-fired; 3. natural gas-fired; and 4. renewable fuels. If a coal-fired plant replaces Vermont Yankee and Middlebury College switches to GMP, Middlebury will emit 2,070 MTCDE less than if it remains with CVPS. If an oil-fired plant replaces Vermont Yankee and Middlebury College switches to GMP, Middlebury will emit 1,770 MTCDE less than if it remains with CVPS. If a natural gas-fired plant replaces Vermont Yankee and Middlebury College switches to GMP, Middlebury will emit 1,300 MTCDE less than if it remains with CVPS. If an electric utility that uses renewable energies replaces Vermont Yankee, however, Middlebury College should remain with CVPS, as it would emit 160 MTCDE less per year than if it switched to GMP (See Table III.5).

Table III.5. CDE Emission Comparison[a]

(2000 - before VT Yankee goes offline)[c]

	GMP			CVPS		
Fuel Type	Total %	KWH	CDE (tonnes)	Total %	KWH	CDE (tonnes)
Natural Gas	2.1	418,220	298	0	0	0
# 6 Oil	2.0	398,305	398	2.7	537,712	537
Nuclear[b]	30.8	6,133,899	659	41.1	8,185,170	878
Total	34.9	6,950,424	1,355	43.8	8,722,882	1,416
Emissions Difference			-61			61

(2012 - after VT Yankee goes offline)[d]

	GMP			CVPS		
Replacement Fuel Type	Total %	KWH	CDE (tonnes)	Total %	KWH	CDE (tonnes)
Natural Gas	32.9	6,552,118	5,075	41.1	8,185,170	6,380
# 6 Oil	32.8	6,532,203	6,825	43.2	8,603,390	8,597
Coal	30.8	6,133,898	7,359	41.1	8,185,170	9,427
Renewables/ Hydro	72	14,338,983	0	97.3	19,377,543	0

Total CDE Emissions Difference[e]

	GMP	CVPS
Replacement Fuel	CDE (tonnes)	CDE (tonnes)
Natural Gas	-1,305	+1,305
# 6 Oil	-1,772	+1,772
Coal	-2,068	+2,068
Renewables/ Hydro	+159	-159

[a] All of the calculations above are based on Middlebury College Emissions Inventory 2000 data.
[a]The CDE associated with nuclear power is an upstream emission, mainly based on the CDE emissions associated with the transportation of new and spent fuel rods, and the massive CO_2 release associated with cement production for the reactor.[10]
[c] In the 2001 table, the total % column represents the % of electricity that was bought by GMP and CVPS (the unrepresented percent of electricity that was purchased by these companies was generated by carbon neutral sources). These percentages were multiplied by the amount of electricity purchased by Middlebury College in 2000 (i.e. 19,915,255 kWh) to calculate the kWh column. The appropriate conversion factors (below) were then multiplied by the kWh to calculate the MTCDE produced by each source (see Table I.2) The MTCDE emitted by each fuel source were added for each company, and are denoted by the row titled "total". The two numbers in the total row were subtracted to obtain the emission difference row, which denotes the MTCDE that would have been emitted by the Middlebury College had it been serviced by GMP and CVPS in 2000.
[d] In the 2012 table, the fuel type column denotes four possible types of electricity generating plants that may replace Vermont Yankee: 1) natural gas; 2) # 6 oil; 3) coal; and 4) renewables. The total % column denotes the % of electricity each company may buy from the replacement electric utility. The kWh column consequently, denotes the number of kWh (based on fuel type) Middlebury College would have bought in 2000, and was calculated by multiplying the total % column by 19,915,255 kWh. The appropriate conversion factors were then multiplied by the kWh to calculate the tones of CDE produced by each source.
[e] In the total difference table, the MTCDE emitted by each replacement fuel source for GMP was then subtracted from the MTCDE emitted by each fuel source for CVPS, giving MTCDE emitted in 2012.

In terms of where CVPS and GMP plan on getting their electricity if and when Vermont Yankee is decommissioned in 2012 (and when Vermont's contract with Hydro Quebec expires in 2015):

- GMP plans to invest more capital in wind energy in the next few years, and expects to begin to investigate alternative electricity generators within the year (2003).[12]
- CVPS on the other hand, is currently working with the Vermont Department of Public Service to develop alternatives to Vermont Yankee (2012) and Hydro Quebec (2015). They are primarily investigating two scenarios: 1) Kyoto compliance, in which case CVPS will emphasize renewables in their new fuel mix; and 2) Kyoto non-compliance, in which case CVPS will emphasize cost effectiveness in their new fuel mix. CVPS additionally, is taking other factors into consideration—i.e. cost minimization, externalities (e.g. emissions), energy efficiency and distributed resources (i.e. buying electricity from a diverse number of electricity utilities). CVPS will most likely have results from this investigation in April or May.[13]

Benefits and Costs

Startup Costs

In order to switch to Green Mountain Power once permissible by law, an initial $1,875 must be paid in start up costs. Additionally, Green Mountain Power may require a security deposit—based on the previous year's electricity consumption (i.e. number of kilowatt hours). This deposit however, may be waived if the consumer has acceptable credit and good financial standing (e.g. if the consumer has never written any checks that have bounced). Assuming there are no extenuating circumstances, Middlebury College should have this deposit waived.

Operating Costs

There will be no operating costs associated with switching providers. In fact, Middlebury College would pay 1.38 cents less per kWh if it switches to GMP, which would have saved Middlebury College $266,889 in 2000 alone. This figure (also denoted in Table III.6) was calculated in the following manner:

- In 2000, CVPS charged Middlebury College 9 cents per kWh, whereas GMP would have charged Middlebury College approximately 7.7 cents per kWh.
- Middlebury College used 19,915,255 kWh in 2000.
- 19,915,255 kWh multiplied by $0.09 = ~ $ 1.8 million
- 19,915,255 kWh multiplied by $0.077 = ~ $1.5 million
- If Middlebury College had been with GMP in 2000, it would have saved approximately $270,00.

Table III.6. Cost savings with GMP.

	Company	
	GMP	**CVPS**
Cost per kWh	$0.0769	$0.09
kWh Usage in 2000	19,915,255	19,915,255
$ Spent on Purchased Electricity	$1,531,483	$1,792,372
Capital Saved	$266,889	$0

Other Costs and Benefits

Environmental. An added environmental benefit of switching to GMP is that it would reduce Middlebury College's emissions of other noxious gases (e.g. NO_x, SO_2, VOCs and particulate matter). Other environmental benefits associated with Vermont Yankee going offline in 2012 are the reduction in hazardous waste production, transportation, and storage costs—an unavoidable byproduct of Vermont Yankee's electricity production.

Social: The social benefits associated with closing Vermont Yankee are threefold: 1) it would reduce concerns associated with nuclear power plant security—i.e. will nuclear power plants be a target of terrorist attacks; 2) it would reduce concerns about waste disposal—i.e. "not in my backyard"; and 3) it would reduce concerns about waste security—i.e. will weapons grade hazardous waste be stolen and used to produce nuclear weapons?

There would be additional social benefits if Vermont Yankee was replaced with an electric utility that used renewable technologies. More jobs would be created for Vermonters if the replacement plant utilized renewable energies (rather than fossil fuels) because for every million dollars spent on oil and gas exploration, only 1.5 jobs are created; for coal mining, 4.4 jobs. Conversely, for every million dollars spent on making and installing solar water heaters, 14 jobs are created; for manufacturing solar panels, 17 jobs; for electricity from biomass and waste, 23 jobs.[14]

Public Relations. The public relations benefits would be many because of the various additional environmental and social benefits—i.e. if Middlebury advocated the replacement of Vermont Yankee by a renewable energy power plant, it could market itself as not only an educational institution that is concerned for the environment, but also an institution that is concerned for, and gives back to, the greater community.

Possible Financing Mechanisms

None needed as the start up costs are small (i.e. $1,875).

Stakeholders

On campus

Middlebury College

Off campus

1.Vermont Yankee Nuclear Power

2.Central Vermont Public Service

3.Green Mountain Power

Examples from elsewhere

Other Colleges and Universities

The following Colleges and Universities have supported the development of renewable technologies by purchasing portions of their electricity from newly developed wind power projects in southwestern Pennsylvania:

1. Allegheny College
2. Bucknell University
3. Juniata College
4. Swarthmore College

5. Dickinson College
6. Franklin & Marshall College
7. Gannon University
8. Gettysburg College
9. Carnegie Mellon University
10. Penn State University
11. University of Pennsylvania

Furthermore, Carnegie Mellon University and Penn State University announced in 2001 that they planned to expand their commitment to wind power by purchasing the output of an additional wind turbine. Consequently, in 2001 the University of Pennsylvania and Carnegie Mellon University (as well as Penn State University) made the three largest retail wind energy purchases in the US—each for 5% of their electric usage.[15]

To read more about what each college has done and is doing, please go to: http://www.eren.doe.gov/greenpower/0402_communergy_pr.html.

Other Institutions

1. *Seattle, Washington.*[16] In July 2001, the Seattle City Council voted on resolutions supporting the goals of the Kyoto Protocol and committing Seattle City Light—the city's public electric utility—to a policy of zero net greenhouse gas emissions. Resolution Number 30359 formalized Seattle City Light's commitment to become the first major utility in the country to achieve zero net greenhouse-gas emissions. As a result between 1990 and 2000, Seattle's CDE emissions were down 48 %, and projections put the city at 84 % below 1990 by the year 2010.

2.*Sustainable Asset Management Company.*[17] Sustainable Asset Management (SAM) is an international, independent asset management company. It achieved carbon neutrality through Future Forests' green technology offset program. To reduce SAM's CDE emissions, it: 1) switched to renewably-generated electricity; 2) it began offering public transportation at reduced rates to all employees; 3) it began promoting train travel for all business trips under 400 kilometers; and 4) it began encouraging teleworking and utilization of telephone conferencing.

Getting Started

1. Investigate the laws governing electricity distribution:
   http://www.eren.doe.gov/state_energy/mystate.cfm?state=vt.
2. Contact Green Mountain Power: www.greenmountainpower.com.
   - customer service 1-888-TEL-GMPC (1-888-835-4672)
   - e-mail: callcenter@gmpvt.com
3. Contact your local Vermont legislator representative, who may be found at the following URL:
   http://www.rutlandherald.com/legislature/guide/senbycounty.html.
   a. Advocate the decommissioning of Vermont Yankee Nuclear Power Plant.
   b. Advocate its replacement with an electricity provider that uses renewable energies.
4. Educate and encourage students to do the same.

III.5 References and Notes

1. Parts taken from http://wings.buffalo.edu/ubgreen/content/programs/energyconservation/reportenergyconsv.html.
2. (http://www.tulane.edu/%7Eeaffairs/ecolympics.html; http://www.tulane.edu/%7Eeaffairs/rules.PDF)
3. http://www.energystar.gov/
4. http://wings.buffalo.edu/ubgreen/documents/programs/energyconservation/guide_computing.doc
5. http://www.clf.org/advocacy/Vermont_Yankee_page.htm; and http://www.eia.doe.gov/cneaf/electricity/st_profiles/vermont.pdf
6. http://www.state.vt.us/psd/vy99.htm
7. http://www.clf.org/advocacy/Vermont_Yankee_page.htm
8. www.greenmountainpower.com
9. http://www.greenmountainpower.com/atyourservice/greenmountainclean.shtml
10. "A Summary of Energy Consumption and Greenhouse Gas Emissions at Middlebury College,", M. D. Dagan, Middlebury College, Middlebury, VT, December 2002.
11. Ms. Dotty Schnure, Green Mountain Power (phone #: 888 - 655 - 8418)
12. Mr. Stephen Terry, Executive Vice President of Green Mountain Power (phone #: 888 - 835-4672)
13. Mr. Bruce Bentley, Central Vermont Public Service (phone #: 800 - 747 – 5520)
14. Gelbspan, R. The Heat Is on: The Climate Crisis, the Cover-Up, the Prescription. Updated ed. Reading, Mass.: Perseus Books. Pp 278. 1998.
15. http://www.eren.doe.gov/greenpower/0402_communergy_pr.html
16. http://www.newrules.org/electricity/climateseattle.html
17. http://www.futureforests.com/forbusinesses/corporate.asp
18. http://www.goodenergy.com/electricity_deregulation/deregulation.asp
19. http://www.goodenergy.com/electricity_deregulation/deregulation.asp
20. http://www.pennfuture.org/items/index.cfm?action=List&pagename=Summary&area=news&category=reports
21. http://www.eia.doe.gov/cneaf/electricity/st_profiles/vermont.pdf
22. http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=47
23. http://www.eren.doe.gov/state_energy/policy_casestudies_pennsylvania.cfm
24. http://www.eia.doe.gov/cneaf/electricity/st_profiles/vermont.pdf
25. http://www.eia.doe.gov/cneaf/electricity/st_profiles/vermont.pdf
26. http://www.eia.doe.gov/cneaf/electricity/st_profiles/vermont.pdf
27. http://www.eren.doe.gov/state_energy/policy_casestudies_pennsylvania.cfm
28. http://wings.buffalo.edu/ubgreen/content/resources/envstewardship.html#sec10
29. http://www.state.vt.us/psb/document/5854/final.htm
30. http://www.tufts.edu/tie/tci/CO2reductions.html#CE

31. http://www.deregulation.com/electric.html
32. www.rff.org
33. David Barboza. A Big Victory by California in Energy Case. Business/Financial Desk. November 12, 2002. Late
Edition - Final , Section C , Page 1 , Column 5.
34. Richard A. Oppel Jr. with John M. Broder. Judge Rejects California Electricity Refund. National Desk.
December 13, 2002. Late Edition - Final, Section A , Page 30 , Column 4.
35. http://www.pennfuture.org/news/8_universalservice_11601.htm
36. http://www.eren.doe.gov/state_energy/policy_casestudies_pennsylvania.cfm
37. http://www.pennfuture.org/items/index.cfm?action=List&pagename=Summary&area=news&category=reports
38. http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=45
39. How global climate change will affect Vermont (EPA website): http://yosemite.epa.gov/oar/globalwarming.nsf/content/ImpactsStateImpactsVT.html
40. More information on electricity restructuring please see:
http://www.citizen.org/cmep/energy_enviro_nuclear/electricity/deregulation/ - 114
http://pnnl-utilityrestructuring.pnl.gov/publications/Primer/primer.pdf
http://www.eia.doe.gov/cneaf/electricity/page/restructure.html
41. Deregulation Estimations of Cost:
http://www.eia.doe.gov/cneaf/electricity/st_profiles/vermont/vt.html - t6
42. Read about Pennsylvania vs. California electricity restructuring
http://www.enn.com/enn-features-archive/1999/10/100399/deregulation_4605.asp
43. Read about the economic impacts of Pennsylvania's electricity restructuring
http://www.revenue.state.pa.us/revenue/lib/revenue/2001_electricrpt.pdf
44. Great database on renewable energy technologies:
http://www.nrel.gov/search.html
45. Database on energy use:
http://www.energy.gov/sources/index.html
46. Environmental Assessment of Green Mountain Power
http://www.greenmountainpower.com/enviro/ceres01.pdf
47. Green Mountain Power Annual Shareholder Reports (2000 &2001)
http://www.greenmountainpower.com/whoweare/annualreports.shtml
48. More information on RPS
http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=47
49. Energy Information Administration, Monthly Energy Review (Table 7.5):
http://www.eia.doe.gov/mer/elect.html
50. Energy Information Administration, Annual Energy Review (Table 8.13):
http://www.eia.doe.gov/emeu/aer/elect.html
51. Energy Information Administration, State Electricity Profiles:
http://www.eia.doe.gov/cneaf/electricity/st_profiles/pennsylvania.pdf

52. Energy Information Administration, Electric Power Monthly (Tables 44-55): http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html
53. Energy Information Administration, U.S. Average Monthly Bills by Sector, Census Division, and State (Table 1): http://www.eia.doe.gov/cneaf/electricity/esr/esr_tabsh.html
54. Energy Information Administration, Electricity Revenue, Sales and Price for Power Marketers (Tables C1-C4): http://www.eia.doe.gov/cneaf/electricity/esr/esr_tabsh.html
55. Energy Information Administration, Electricity Revenue, Sales, and Price by State and Utility: http://www.eia.doe.gov/cneaf/electricity/esr/esr_tabsh.html
56. Energy in Vermont: contacts, statistics, websites, etc. http://www.eren.doe.gov/state_energy/mystate.cfm?state=vt
57. 1996 Economic Impact Study commissioned by the College
58. Based on data from UVM solar project at http://www.uvm.edu/~solar/.
59. http://www.vtsolar.com/
60. http://www.bpsolar.com/ContentDetails.cfm?page=38
61. http://www.pecansolar.com.au/solarpower/faq.php

IV. Transportation

IV.1 Greenhouse Gas Emitting Activities

Faculty and staff commuting, student travel to and from college, student car use on campus and in town, college fleet driving (varsity/JV/club sports teams, admissions, facilities maintenance, golf course, student activities and academic field trips, etc.) are the major components of our transportation footprint. Student and faculty/staff commuting are by far the largest contributors to CDE emissions in the transportation sector. FY 2000 estimates of commuting emissions were 2,667 MTCDE for faculty/staff and 1,492 MTCDE for students. Since 1990, faculty/staff commuting emissions have risen over 30%, while student commuting emissions have increased by about 13%. Our current transportation emissions inventory has several significant omissions within it. The emissions of vehicles rented by Middlebury College are unaccounted for (including sports-chartered buses and vans, and trips by College admissions and advancement staff), and student commuting and general car usage are not well documented. Currently only a single round trip to and from campus is included in the emissions inventory for each student. Strategies to limit student car use by providing alternatives are currently based on assumed usage and an estimated number of trips each year. Nonetheless, if successful, these strategies to limit student cars by providing shuttles would greatly reduce CDE emissions. These strategies would serve not only to directly reduce CDE emissions from student driving, but also indirectly by creating the type of institution where car-dependency and ownership become increasingly unnecessary for the average student. Shuttles could be provided to the airport, Snow Bowl, the city of Burlington on the weekends, and Boston and New York City at the beginning, mid-point and end of semesters to reduce CDE emissions and enhance the attractiveness of the College for prospective students.

IV.2 Primary Stakeholders

All Middlebury College community members will undoubtedly be affected by transportation policy and infrastructural changes – Middlebury students, faculty, staff, administration, Facilities Management, Facilities Planning and Purchasing are a few of the myriad on-campus stakeholders. Numerous off-campus stakeholders will also be impacted by changes in transportation planning-- the Town of Middlebury (Fred Dunnington: Town Planner; Garrett Dague: ACRPC transportation planner), current fuel suppliers, alternative fuel suppliers (Dog River), vehicle suppliers (purchases), vehicle suppliers (rentals: Premier Coach, Thrifty, Fosters, Bristol Tours), other NESCAC schools, and mass transit providers (shuttle/bus rentals, ACTR). Last, but not least, members of our extended College community- alumni, family, friends and visitors- will all be affected by increased transportation options and policy changes.

IV.3 Summary of Objectives

1 Reduce vehicle miles traveled (VMT)

Objective 1 (reducing VMT) includes policies and programs that, over the next 10 years, would directly reduce the volume of motor vehicles and their use, therefore we have identified limiting the number of student cars on campus, encouraging student/faculty/staff carpooling and reduced college fleet use as the major strategies to achieve this objective. Reducing VMT is the best way to cut GHG emissions because it is a source reduction. Nationally, longer commuting distances, more trips generated, and greater numbers of vehicles on the road have offset improvements in fuel efficiency. Therefore, reducing the overall vehicle miles traveled associated with Middlebury College activities recognizes and embraces the idea that technology alone will not eliminate our transportation emissions anytime in the foreseeable future.

2 Switch to cleaner, more energy-efficient vehicles

Within the objective of switching to cleaner, more energy efficient vehicles is the opportunity for the college to replace its current vehicle fleet with equivalent vehicles that emit no CDE or significantly less CDE during their operation. There are apparent costs associated with these cleaner, more energy efficient vehicles. However, after calculating the cost difference associated with replacing these vehicles with a more efficient equivalent (as opposed to replacing with the same vehicle type), we have seen it to not be overwhelming. Each of the fleet vehicles will be replaced eventually, and the funds saved on reduced fuel consumption by efficient alternatives are significant. Although a policy cannot be implemented to replace student, faculty, and staff vehicles with cleaner, more energy efficient vehicles, strategies to encourage these efforts can be. We have suggested implementing incentives for college community members who are looking to replace their vehicles with more efficient models. We might also implement emissions regulations which, if not met by each vehicle owner, would require him/her to pay the corresponding CDE emissions offset.

3 Switch to cleaner fuels

In addition to cutting CDE emissions of diesel-fueled vehicles in half, there are many additional benefits derived from switching fuel consumption to biodiesel. Biodiesel is a non-toxic, non-corrosive, non-combustible, non-volatile fuel. Biodiesel has a higher viscosity when it is injected into the engine, and thus acts as a far better lubricant than conventional synthetic diesel fuel. As such, it reduces the overall noise of the engine, and tends generally to extend the overall life of the engine. Biodiesel provides miles per gallon performance equivalent to synthetic diesel, with equivalent horsepower and acceleration performance as well. Perhaps the greatest benefits associated with the switch to biodiesel fuel are the social and economic changes it supports within the state and country. The potential exists now for a community to grow some fuel for its own consumption, providing a radical alternative to paying fuel corporations and disrupting the geological cycle. We believe that the possibility for fuel creation and consumption to become more localized is an exciting one, perhaps one day making oil drilling, tanker trucks filling highways, and disastrous oil spills a thing of the past.

4 Develop alternative transportation

In concert with institutional and economic incentives for reducing VMT, developing alternative transportation programs and infrastructure can replace and provide for individual transportation needs. This objective includes public transportation (shuttle bus) around town and in the region, as well as improved on-campus infrastructure for non-motorized forms of transportation. In addition, we recommend providing shuttles for students to travel to airports and major metropolitan areas at the beginning of, during breaks in, and at the end of semesters, as well as providing shuttles to the Snow Bowl, Burlington, Montreal and Boston on weekends. These efforts would offset the need for student-owned vehicles.

5 Reduce transportation needs (IV.4 Future Considerations)

Objective 5 is the most difficult and comprehensive. However, in the long-term, offsetting car-dependency and car-oriented development has the highest potential for reducing transportation CDE emissions. Personal car use is by far the greatest contributor to our campus transportation footprint. Cars are useful and helpful for many reasons, yet we should not let that fact prevent us from exploring ways to reduce car-dependency. Saying that we have no other choice is not an option. If we need cars to pick our kids up from school that is not a reason for giving up, rather, it is an identifiable challenge with a solution. Many of us have kids that need to be driven around; the solution is simpler than it seems: sharing rides and vehicles! Right now we are taking an individualistic approach rather than searching for a creative community approach. We need to pool our resources and our efforts to provide on-campus childcare and either hire or find volunteers to pick up kids from school and take them where they need to go. The objective is to reduce the number of vehicles and VMT involved in this process. We need to find ways to share responsibility for the benefit of our community, the health of our natural environment and for the security of our economy and the global community. Objective 5 includes far-reaching and innovative strategies that recognize the comprehensive nature of this problem. Low-density living incurs an increased number of trips and miles traveled per household. While some individuals prefer living in more rural areas, others would prefer and/or would be willing to sacrifice country-living in return for reduced cost of transportation, reduced time spent commuting and chauffeuring our kids around, and increased convenience. This lifestyle is only possible with increased availability and affordability of housing in population centers such as Middlebury. Telecommuting is also an effective way of reducing the need for commuting- even if it were one fewer day each week, the impact would still be enormous!

IV.3.1 Reduce vehicle miles traveled

Summary of Strategies

a. Limiting student vehicles on campus and imposing a $50-$100 annual parking fee

b. Provide incentives for student carpooling (Rideboard)

c. Provide incentives for faculty staff carpooling and alternative commuting options

d. Reduce use of campus fleet (bike patrols and delivery, shut-off engines)

IV.3.1.a.– Limit student vehicles on campus and impose a $50-$100 annual parking fee

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
49	None	250	$ (512)

To achieve an immediate ~30% reduction in the number of student vehicles on campus, we recommend banning freshmen and sophomores from bringing cars to campus, while charging juniors and seniors $75 for parking permits. This $75 fee will be cut from the student comprehensive fee for all students, thereby offsetting the cost of parking for students that may not be able to afford it, as well as providing an incentive to those students that opt not to bring a car to Middlebury. This proposal is clearly an enormous shift from our current policy, which is already controversial. However, limiting student cars on campus is not unheard of. In fact, preventing first-years from bringing cars to campus is a popular strategy for NESCAC schools and has compelling environmental and social ramifications. In addition to reducing emissions, limiting student cars on campus will have the additional effects of increased safety, fewer car accidents, a better town-college relationship, good public relations, improved freshman class integration and solidarity, and the educational opportunity for students to experience “car-lessness.” By the time upperclassmen are allowed to bring cars to school, many will likely opt to not do so, or they may bring automobiles but use them infrequently.[1]

Timeline

This strategy can be implemented in two years. Starting 2003-04, freshmen will not be permitted to bring vehicles to Middlebury. The following year (‘04-‘05), and all subsequent years, the incoming freshmen and sophomore classes will not be permitted to bring vehicles to Middlebury.

Magnitude of Potential GHG Reduction

There were, over the last 5 years, an average of 1200 registered student vehicles each year.[2] During the FY 2002-2003, approximately 1/3 (400 vehicles) were Freshman and Sophomore vehicles. Based on these rough numbers, we estimate that banning Freshmen and Sophomore cars will yield at least a 30% reduction in the overall number of vehicles and therefore at least a 30% reduction in CDE emissions associated with student driving--approximately 500 MTCDE. However, these students will still need to commute to school at the beginning and end of semesters and during breaks. Parents, siblings and upper-classmen would all likely drive these students back and forth from school. Regardless, there will still be a high CDE emissions associated with student commuting, unless mass transit alternatives are available. Therefore, the 500 MTCDE figure is unrealistic-- 250 MTCDE is a better estimate (albeit very rough). Still, the reduction in emissions associated with eliminating freshman and sophomore car use around campus and the Town of Middlebury, as well as trips to the Snow Bowl, Montreal, Burlington, etc. would be quite high (an estimate for this figure is included in Objective IV.3.4). Charging $75 for parking permits may also reduce the numbers of Juniors and Seniors that register vehicles.

Benefits and Costs

Fixed Cost

A modest amount of staff time would have to go into coordinating these proposed changes in vehicle policy. For consistency, we will assume that this will be approximately $5000 of staff time for this strategy and each of the transportation policies proposed in this section.

Variable Cost or Benefit

In order to undertake this strategy, we recommend reducing the student comprehensive fee for all students by an amount equivalent to the $75 fee charged for parking. Given this scenario, the College would sustain a projected annual loss of $75 from each student, which would be approximately 2500 X $75 = $187,500. Some of this loss would be then be recouped by the parking fee, depending on the number of students registering vehicles: if we assume 800 registered student vehicles, this would be 800 X $75 = $60,000. Accordingly, the annual variable cost for this program would be: $187,500 - $60,000 = $127,500.

It should be noted that strategy will further reduce current operating costs because fewer students will be registering vehicles and therefore fewer vehicles will need to be monitored by public safety. Reducing the number of student vehicles will also reduce need for additional parking spaces, thereby lowering Facilities Planning and maintenance costs. However, there may be additional costs associated with monitoring unregistered student vehicles off campus.

Other Costs and Benefits

Social. Students will become more accustomed to life without car ownership and therefore may be less likely to be dependent on cars in the future. A car-less freshman class will promote solidarity among incoming students. Students will have to share resources and spend time traveling with and getting to know one another. Under-classmen will have to meet and travel with upper-classmen promoting greater overall community solidarity and integration.

Limiting cars on campus will likely reduce the risk of drunk-driving and weather-related accidents.

Public Relations. Banning Freshman and Sophomore vehicles will be highly controversial on our campus, but will most likely result in excellent long-term public relations for the College. Not only will Middlebury College likely be recognized nationwide for our initiative, but the Town of Middlebury would probably be greatly appreciative of the reduced volume of student traffic. There will be some complaints by parents and students who feel their kids should have special privileges, but these claims will not hold up under public scrutiny: we feel that the disgruntled concerns of a few should not be placed above the overall community good. If we are committed to increasing the diversity of our applicant pool, limiting cars on campus and investing in alternative transportation are no-brainers! Socially and environmentally conscious transportation reform will not occur without the active participation of influential institutions-- it is our hope that Middlebury College will opt to be on the vanguard of this movement.

Cross-cutting synergies. Once again, we would like to reiterate that limiting student car use is not an option without providing alternatives. For that reason, other strategies in the Transportation section would need to be implemented as well, and several items in the "Future Considerations" should be given close attention (promoting the return of the passenger train to Middlebury and the "Pedestrian-friendly" campus).

Possible Financing Mechanisms

This change would need to be accounted for in long-term planning of the school's tuition comprehensive student fee.

Stakeholders

On campus

Students (Ginny Hunt and Ben Labolt: SGA president and SCCOCC), administrators (Executive Council and Community Council members), the Admissions Office, the Department of Public Safety (Lisa Boudah), Facilities Planning (Dave Ginevan, Tom McGinn) & Maintenance (Norm Cushman) should all be involved in any changes to current policy.

Off campus

Parents of incoming students would need to be informed immediately of any changes in policy. The Town of Middlebury, Vermont State Highway Patrol, Ambulances and local hospitals would probably all welcome the College's efforts to reduce the number of vehicles on the road.

Examples from elsewhere

Other Colleges and Universities

Table IV.1 indicates student car policies at a variety of other comparable colleges.

Table IV.1 Comparison of College Student Car Policies.

College						

	Car policy	First year cars?	Yearly fee	Cars registered	Enrollment	Percentage of students with cars
Amherst		N	$60	570	1750	33%
Swarthmore	Junior & senior only, by permission of student-run committee	N	none	130	1500	9%
Williams	"[Williams] does not encourage possession of a motor vehicle nor consider it a necessity in any way"	N	none	675 (but only 600 parking spaces)	2113	32%
Wellesley		N	$135	~900	2500	36%
Pomona	"only 1 car per student"	Y	$60	575	1464	39%
Middlebury		Y	none	1034	2265	46%
Carleton	No cars except off-campus students (1 per house) and medical/employment excuses; other cars in "dead storage" except at vacation Runs 3 buses daily to Twin Cities	N	none	~200	1750	11%
Haverford		N	$30	325	1200	27%
Bowdoin		Y	$25	~600	1600	38%

Data source: Campus Security offices and official college publications

~ indicates approximate value

Compiled by R. Wolfson, Department of Physics, Middlebury College, Fall 2000

Getting Started

Contact Admissions, so they can inform incoming students. Get in touch with Student Affairs and have them include new policies in orientation. Contact Cashier's Office and Bursar about lowering Comprehensive fee by $50-$100. We recommend that all of these individuals and those mentioned in the "On campus stakeholders" section schedule a meeting in the Spring to discuss the details and the organizational necessities of this strategy.

IV.3.1.b – Provide Incentives for Student Carpooling (Rideboard)

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
38	None	100	$ (12)

A user-friendly, easily accessible Rideboard could potentially reduce student VMT. Students make many "redundant" trips to the airport, Burlington, Boston and other destinations because they lack the time, initiative and desire to share rides. SGA promoted and created an on-line Rideboard last fall. All that remains to be done is increase its visibility and accessibility. We recommend including incentives for offering rides on the Rideboard (in addition to the incentive of shared gas costs): students that offer four rides a year, will be eligible to have their parking fee rebated at the end of the year. The rebate process could be similar to the way that room-key deposits are currently returned to students at the end of the year. We would make vehicle registration mandatory at the beginning and end of the year. Public Safety will be informed of those individuals that offered 4 or more rides on the Rideboard and will return the $50-$100 parking fee at the end of the year when students check out. The rebates would be a loss of potential revenue (If 25% of students offered 4 or more rides on the rideboard and had their parking fee waived at the end of the year, we would lose 25% of what we would have collected in parking fees) but the goal of increased ridesharing would hopefully be achieved.

Timeline

The Rideboard is already on-line. The Rideboard can be improved within months and usage will increase if more individuals offer rides. A Rideboard is a valuable, low-cost mechanism for reducing VMT.

Magnitude of Potential GHG Reduction

If the Rideboard could reduce trips made by 75% -- using estimated 2000 student VMT-- the Rideboard could offset 100 tonnes MTCDE/year. Because students travel to many of the same locations, the Rideboard could potentially have an even greater impact.

Benefits and Costs

Fixed Cost

Re-designing the on-line Rideboard to track the individuals that offer rides will have a low associated cost equivalent to the salary for the web-designer. We estimate that for a student worker, this would be no more than $2000.

Variable Cost or Benefit and Benefits

Keeping track of and relaying Rideboard information to the Dept. of Public Safety to rebate students would have an associated administration and maintenance cost. We estimate that this would be about $1,000 year.

Other Costs and Benefits

Social. Enhance community solidarity and sense of shared responsibility to fellow students. This strategy would probably result in increased awareness of car-less students and their needs. In addition this strategy may reduce the potential for car accidents resulting from students falling asleep because they were driving alone. Students will share gasoline costs.

Public Relations. If this program succeeds, the College could set an example for other institutions for offering a creative incentive-based Rideboard.

Possible Financing Mechanisms

Start-up and operating costs could be covered by revenue from the annual student parking fee after the first year.

Stakeholders

On campus: Students, Department of Public Safety, ITS, SGA, Dean of Student Affairs, Cashier's Office, Administration.

Off campus: Other NESCAC schools may be encouraged to adopt a similar program depending on the success of our on-line Rideboard.

Getting Started

Contact Ginny Hunt (SGA President), ITS, Lisa Boudah and Doug Adams (CCAL). Schedule a meeting this Spring between an SGA representative, the web-designer, the head of the Cashier's Office/Bursar and the individuals at Public Safety that would be rebating students at the end of the year to discuss the administrative and organizational details of implementing this strategy.

IV.3.1.c – Provide parking rebates for faculty/staff and charge $75 for registering a vehicle

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
46	None	130	$ (592)

This strategy would involve the College charging faculty and staff to park on the campus, and then giving a parking rebate to all faculty and staff that participate in rideshare/carpool or that walk, bike or ride the shuttle (i.e. those not using a parking spot).

Timeline

Could be easily implemented next year.

Magnitude of Potential GHG Reduction

For the purposes of this report, we will use an estimated 5% reduction in overall faculty/staff commuting as a realistic (yet rough) estimate-- given an imposed $75 registration fee to compensate those not driving to work. Based on a 5% reduction in FY 2000 faculty/staff commuting (2,667 MTCDE), the estimated CDE reduction would be around 130 MTCDE/year. In all likelihood this number could be potentially higher and will probably continue to grow annually, based on current growth rates, to 175 MTCDE/year offset by 2010-- given a 5% reduction in faculty/staff CDE commuting emissions.

Benefits and Costs

Fixed Cost

The startup costs would be modest, approximately $5000 in staff time to initiate the program. All faculty/staff vehicles would have to be re-registered; those involved in a carpool group would be given a different sticker for their car and still remain eligible for a parking rebate. Including the rebate program in the College finance/payroll department would also require time and resources.

Variable Cost or Benefit

The variable costs and benefits of this program are associated with three proposed changes in the faculty and staff parking policy: a salary increase of $75, a fee of $75 to park on campus; and a rebate to all faculty and staff that participate in rideshare/carpool or that walk, bike or ride the shuttle.

- A salary increase equal to the amount charged for registering a vehicle ($75) would guarantee that the College as an institution is taking financial responsibility to reduce emissions. In this case, the College would be spending an additional amount of money each year -- $75 X number of total employees (~1,200)= ~$90,000/year).
- Like students, faculty and staff would be expected to pay $75 per year for a parking sticker.
- We recommend a rebate of $1200/year to all faculty and staff that, instead of parking their own car on campus, participate in rideshare/carpool or that walk, bike or ride the shuttle. We believe that the $1200 rebate is high enough so that at least 5% of faculty/staff – 60 people – would be likely to opt for a parking rebate. The $1200/year figure is based on federal standards, but we may find that a smaller value (if employee vehicles registration drops below 90%) may achieve the same goals

Using the FY 2000 figure for Faculty & Staff of 1200, and given that 5% of commutes are by means other than single-occupancy motor vehicle (i.e. 60 faculty/staff), the total revenue from an annual parking fee of $75 (not charged to those carpooling that share a parking spot) would be (1200-60) X $75 = $85,500.

Overall, the college would lose $90,000/year from the salary increase and $72,000/year from the rebate program, but then take in $85,500 from the parking fees. Therefore the net cost of these three changes would be $76,500.

Other Costs and Benefits

Environmental. Fewer employee vehicles on campus would encourage less driving around town before, during and after work, thereby indirectly lowering CDE emissions. It would also reduce associated hydrocarbon and smog-forming pollutants.

Social. Fewer cars on the road will lead to less downtown traffic, thereby improving the aesthetics and safety of downtown Middlebury. Individuals that adjust their lifestyles to become less car-dependent can potentially save money on car payments, gas, vehicle repairs, and insurance, and, in addition will lower the risk of being in motor vehicle accidents.

Public Relations. Positive environmental and social public relations for the College, plus the Town would love reduce the number of cars on the road.

Possible Financing Mechanisms

VPTA facilitates leasing and loans for individuals interested in acquiring a carpool/vanpool vehicle. They also provide "emergency ride" compensation (they pay for taxis if a carpool falls through or if an emergency comes up). The parking fee will begin to generate a large revenue source to fund alternative transportation options (park & ride facilities, more shuttles) and offset transportation needs (on-campus childcare/after school care).

Stakeholders

On campus

Public Safety, Faculty/Staff, Administration

Off campus

Town of Middlebury, Faculty/Staff families, local businesses, VPTA

Examples from elsewhere

Other Colleges and Universities

UVM charges faculty/staff graduated fees based on salary and charges heavy fees for parking violations that are taken out of salaries to ensure compliance (Gioia Thompson, Personal Communication).

Other Institutions

Vermont Public Transportation Association (VPTA) has a network of and a matching program for car pools. They also have an "Emergency Ride Home" program that reimburses registered members up to eight times a year for emergency taxi use (see http://www.vpta.net/publicservice_job_emergnc.html). VPTA also offers a program through which employers can give $100/month parking rebates to employees: tax- deductible for the employer and tax-free for the employees. Middlebury College would not be able to apply for this program because of its non-profit tax status but other institutions utilize this tax incentive mechanism. VPTA also helps fund loans for purchasing and leasing car pool vehicles.

Getting Started

We would first have to educate employees about rideshare/carpool options and instructions for registration with the state program. This would be a relatively simple matter- a memo with the new vehicle registration policy listing the VPTA website and telephone number as resources for those individuals who choose to participate. A longer-term task is identifying Park&Ride locations along Rte 7 and in town centers for employees to meet and share rides (contact Garrett Dague at ACRPC to discuss funding and proposals). Based on the commuting inventory over the last few years, establishing Park&Ride lots in Cornwall, Weybridge, Bristol, New Haven, Vergennes, Shoreham, Salisbury, Bridport, Ripton and Brandon would be most useful (Shoreham, Bridport and Bristol in particular because of their high associated total VMT). Park&Ride lots are common in Vermont but are non-existent in Addison County, check out the

VPTA site to see what other counties and regions have done (http://www.vpta.net/publicservice_job_parkride.html).

IV.3.1.d – Reduce use of campus fleet and improved efficiency

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
29	0.6	150	$ 52

Reducing the use of campus fleet could include increased bike patrolling for Public Safety officers and facilities personnel during "good" weather; student volunteer or employed bike couriers, shutting off engines while vehicles are parked; using lighter pick-up trucks with better gas mileage for lighter load trips (example: if grounds crew transports shovels, they wouldn't need to use the larger pick-up trucks); sharing multiple tasks in one trip (example: transport the individuals and tools for three tasks in one truck that drops off and picks up the others).

Magnitude

If we reduce fleet use by 5%, we would reduce 150 MTCDE/year at $0/tonne.

Benefits and Costs

Fixed Cost

The startup costs would be modest, approximately $5000 in staff time to establish changes in fleet-use policy.

Variable Cost or Benefit

A reduction in fuel use of 5% would result in an annual savings of $8,300, based on current prices for gasoline and diesel fuel. The loss of staff time associated with some changes – for example, bicycling as opposed to driving – is not estimated here.

Other Costs and Benefits

Cross-cutting synergies- strategies for reducing use of fleet would also be included under Objective 5: "reducing need for transportation," with such strategies as "self-heating paths" and "low-maintenance/energy-efficient" landscaping. More labor intensive but less fuel intensive landscaping could be growing crops for bio-fuel cultivation or food consumption and could also sequester additional CO_2 from the atmosphere. The possibilities are exciting and far-reaching.

Getting Started

We recommend eliciting suggestions from various departments and offices on ways to increase efficiency, limit vehicle use and encourage biking.

IV.3.2 Switch to cleaner more energy efficient vehicles

Summary of Strategies

a. Replace gasoline fleet with electric vehicles

b. Replace gasoline fleet with diesel vehicles

IV.3.2.a – Replace gasoline fleet with electric vehicles

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
36	None	71	$ (57)

There are 12 gasoline 4x2 gators manufactured by John Deere running in the campus fleet along with 40 gasoline golf carts manufactured by Yamaha. John Deere does manufacture an electric model gator that provides relatively equivalent performance. Yamaha also manufactures an electric model golf cart with equal performance ratings. These electric vehicles produce no emissions and operate very quietly. Yamaha's electric models can be purchased for an equal or lesser price than their gasoline equivalents. John Deere's electric gators are $1,400 more expensive than their gasoline models. These electric vehicles each run on either a 2.5 or 2.8 kW motor which operates for 12 hours on a full charge (requiring 12 hours to recharge). At our current purchasing prices for electricity this works out to about $8.84/charge. Although a considerable amount of money would be saved from not purchasing fuel, the cost of charging these vehicles would be relatively equal or possibly greater. Nonetheless, this has a great potential for reducing CDE emissions and in all likelihood will eventually become profitable. As gasoline prices continue to rise, the money saved each year on fuel will increase accordingly. Likewise, as the college continues to investigate and establish cheaper and more renewable sources of electricity the cost of charging these vehicles will diminish.

Timeline

The replacements could occur at within the physical year from college funds or through the formation of a loan. The existing golf carts and gators (all models within 1990-2002) could be resold for ¼-1/3 of their purchased price (between $1,000-$2,000 per vehicle). Whether each vehicle was replaced with an electric equivalent once "its number is up," or whether the entire fleet is replaced at once is flexible. There would certainly be cost reductions/awards from John Deere and Yamaha were we to choose to buy in bulk. The vehicles would gradually pay themselves off over the years as the college would no longer be paying for increasingly expensive gasoline to fuel them and would be implementing increasingly more cost effective ways of supplying electricity to charge them. At the start of this project the college would need to establish a storage/docking area at which these vehicles could be recharged. Clearly on campus space considerations would be applicable. Once established the lifetime of this project is indefinite or proportional to however long the college produces and consumes electric power. Its benefits would only grow as the college begins to move toward solar and wind sources of electricity.

Magnitude of Potential GHG Reduction

There is a potential reduction of 71 MTCDE associated with replacing twelve gasoline gators and 40 golf carts with electric equivalents. This figure is based on these assumptions:

-That each gator runs for 2 hours for each day of the year at 0.4 gallons of gasoline per hour.

-That each golf cart gets 23.3 mpg and can run for 30 rounds on one (six gallon) tank of gasoline.

-That each golf cart is filled up with gasoline once per year.????

-For every gallon of gasoline consumed, 0.013063 MTCDE are emitted.

This figure of 71 MTCDE might be larger if the gators are operating for more hours annually, or this figure might be smaller if they are operating for fewer hours. It is also important to remember that there is not necessarily a net zero CDE emission associated with this strategy due to the CDE emissions associated with the electricity needed to charge the electric vehicles and with supporting the charging facility itself. These emissions and costs would fall within the Space Heating and Cooling and Electricity sectors, however, the CDE emissions would in most cases be limited to upstream emissions.

Benefits and Costs

Fixed Cost

Replacing the twelve gasoline gators would cost an additional $16,800, since each is approximately $1400 more expensive than its gasoline counterpart. We believe that the cost of locating, designing, and constructing an area to recharge these vehicles could be kept within $2,000-$5,000 as an existing parking garage stands for the gators as does an existing parking patio for the golf carts.

Variable Cost or Benefit

With driving hours equal to their current level of operation, the electricity cost of charging 40 golf carts annually is $3,200 and the electricity cost of charging 12 gators is $6,453. When these prices are offset with what we would no longer be paying for gasoline, the total cost of charging these 52 vehicles would be roughly $2000 dollars annually. Maintenance costs would be equivalent to what they are now. Again this price would certainly decrease as gasoline prices increase and local renewable energy becomes more viable.

Other Costs and Benefits

An added benefit to the CDE reduction of electric vehicles is their significant reduction in noise pollution. A possible cost associated with these vehicles is a possible decreased performance level during winter operation, (this is obviously a more significant issue to address for the gators than for the golf carts). All of these gators and golf carts will eventually need replacement. These electric vehicles have the same relative lifespan as their gasoline equivalents. The social benefits associated with switching a portion of the campus fleet to electric are immeasurable as it would not only brighten the college's reputation in town and the surrounding area, but would send a strong message of commitment to carbon reduction to other colleges and universities worldwide.

Possible Financing Mechanisms

The college might allocate funds for these replacements through the purchasing department, or perhaps establish a loan based on the anticipated payback time of the vehicles during regular operation. Also, perhaps generous alumni who frequent the golf course might consider supporting such an initiative. As much as $80,000 might be recouped from the resale of each of the 52 gasoline vehicles (each vehicle yielding 1/4 – 1/3 of its purchased price).

Stakeholders

On campus

-Facilities Maintenance, administrators, Purchasing Department, Mailroom, Golf Course personnel.

Off campus

-Golf course frequenters, John Deere, Yamaha, gasoline fuel providers, electricity providers.

Examples from elsewhere

Other Colleges and Universities

-*York Technical College* of Rock Hill, South Carolina currently owns and operates 21 electric vehicles in their campus fleet.

-*Houghton College* of New York has recently added an electric vehicle to their fleet, the first with Nickel Metal Hydride batteries to be acquired by a private institution in New York State.

-*Middlebury College* leases a 1996 Chevrolet electric pickup truck from E-Vermont Solectra which has proven to perform well in the winter, traveling 50-60 miles on a 3-5 hour charge.

-*Warren-Wilson College* has installed a solar electric-vehicle charging station to power 11 utility cars.

Other Institutions

-Various businesses and municipal facilities around the country and the globe are aware of the benefits of electric vehicle technology and have begun to research and implement the technology into their practices.

-In Canada, the Alternative Fuels Act requires that 50% of all new government vehicles purchased must be able to run on alternative fuels and the requirement will rise to 75% by the year 2004.

Getting Started

It would first be beneficial to establish a committee or working group on electric vehicles. It would be necessary to assess the feasibility and location of a possible structure/dock necessary to recharge these vehicles at. This would require communication with campus planners as well as a local construction/architectural firm. It would be useful establish contact with E-Vermont Solectra through who we lease our electric pickup truck. There will need to be further information gathered from the Facilities Management department concerning their gators and general gator use patterns. The same would be necessary with the golf course employees and frequenters. Once hard numbers are crunched for this project's total potential negotiations can begin with John Deere and Yamaha concerning various logistics (prices, delivery, charging, maintenance, warranty, resale of current vehicles, etc.) Upon this greater level of communication and understanding with the above groups, the school administrators and purchasers would then be approachable by this working group/committee.

IV.3.2.b – Replace gasoline fleet with diesel vehicles

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
16	8.8	5	$ 390

There are currently 22 gasoline vehicles in the college fleet that could potentially be replaced with diesel-fueled equivalents in the future - 12 trucks, 4 large vans, 4 gators, and 2 mowers are included in this list.

Timeline

As with the electric vehicle strategy, whether the college chooses to replace all 22 of these vehicles with diesel equivalents immediately or as each one needs replacing will need to be determined. Again, there would certainly be a cost reduction if the switch were made all at once. The sooner the switch is made to diesel the sooner the college will start saving money on fuel. The facilities for diesel fuel storage and distribution are already in place as are the facilities to store and maintain these vehicles.

Magnitude of Potential GHG Reduction

The magnitude of the potential reduction was calculated assuming that .000789 fewer MTCDE are emitted for each gallon of diesel that is consumed rather than gasoline. The magnitude of this reduction is somewhere between 3.2 and 7.4 MTCDE each year. These high and low estimates are based on a relative range of miles driven by each vehicle (most lie within 1,000-10,000 miles each year.) And there exists even greater potential for CDE emissions reduction in the switch to diesel vehicles due to the increased ability to burn bio-fuel (See IV.3.3.a).

Benefits and Costs

Fixed Cost

Under the assumption that diesel counterparts to these vehicles would be each be approximately $2,000 more expensive, the associated cost of replacing all 22 of these vehicles would be approximately $44,000. This estimate was determined assuming each diesel vehicle would cost $2,000 more than its gasoline equivalent. This cost may be an overestimate, as, in some cases, the diesel vehicle prices may be closer to their gasoline equivalents – for example, with the mowers.

Variable Cost or Benefit

Approximately $5,000 will be saved annually in the switching of fuels. The lifetime of this proposed replacement would be limited by the lifetime of the replacement vehicle: diesel vehicles would last considerably longer than their gasoline counterparts under the same conditions - approximately 15 years.

Other Costs and Benefits

Although there is a minimal potential reduction in MTCDE associated with these replacements, diesel technology has many added benefits. Diesel fuel, although it is derived from the same fossil fuel resources as gasoline, does not undergo the chemical and industrial refining process to the same extent as gasoline fuel. Diesel vehicles have a much longer lifespan than gasoline vehicles with less maintenance and greater reliability of the engine.

Diesel fuel does have the potential to gel in extremely cold temperatures. This problem can be solved with a simple fuel additive.

Possible Financing Mechanisms

The college might allocate funds for these replacements through the Purchasing Department, or perhaps establish a loan based on the anticipated payback time of the vehicles during regular operation.

Stakeholders

On campus

-Facilities Maintenance, administrators, Purchasing department

-Vehicle users (Dining Service, Breadloaf, Snow Bowl, grounds crew, landscaping, recycling, auto shop, general services, crew club, electric, plumbing, earthworks)

Off campus

-Vehicle manufacturers (Ford, Dodge, John Deere, Chevrolet, Jacobsen, Textron, Wuling, Workhorse)

-Gasoline and diesel fuel providers

Examples from elsewhere

Other Colleges and Universities & Institutions

Most colleges and universities across the country and around the world use diesel vehicles in their campus fleets. Diesel technology is well proven and its benefits are implemented in much of the heavy load work required by colleges, universities, institutions, and municipal facilities worldwide.

Getting Started

Because this technology is so well known and has been proven beneficial, it will not require the kind of research and consideration that electrical vehicles might. The first steps here will be to establish contact with all of the above stakeholders to determine whether diesel fueled vehicles would at all affect their general vehicle usage needs. At this point it would be advisable to be in contact with vehicle manufacturers before making any conclusions about purchasing vehicles. The same would certainly be true for the reselling of any of the existing gasoline vehicles.

IV.3.3 Switch to cleaner fuels

Summary of Strategies

a. Switch diesel fleet to bio-fuel

b. Encourage chartered diesel buses to use bio-fuel

IV.3.3.a – Switch diesel fleet to bio-fuel

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
41	None	440	$ (106)

Currently Middlebury College runs a fleet of 238 vehicles, 43 of which are diesel fueled. Approximately 71,520 gallons of diesel fuel were purchased at $0.72/gallon and consumed by the college in the year 2000. With diesel technology, there exists the potential to run the engine on biodiesel, a vegetable oil-based fuel.

As new and exciting as much of the research concerning biofuels is these days, it is nothing new. The original diesel engine invented by Rudolf Diesel in 1900 ran off of peanut oil. It was not until the 1940's that synthetic diesel fuel as we know it today came on to the market. It had the benefit of being cheaper to acquire through the newly emerging oil economy and did not require the physical labor associated with growing seed crops to crush into oil. We are now witnessing what has been a complete revolution of this market as oil prices are rising, and vast expanses of agricultural land is being left unused with the potential to be growing fuel for vehicle consumption.

We are proposing that Middlebury College lead the way in demonstrating the capabilities of this technology. There are numerous existing biodiesel processing facilities in this country, and more will be established soon. Here in Vermont, Dog River Alternative Fuels delivers low cost biodiesel fuel to consumers statewide.

Timeline

Switching the fuel consumption of the diesel vehicles of the campus fleet to biodiesel does not require any modifications to the vehicles' engines. The fuel could be delivered and begin being consumed as soon as next year, if not sooner. Dog River is more than willing to negotiate a fuel contract as soon as possible. They will deliver the fuel as well as pick up the empty barrels. There currently exists an empty underground storage tank next to the diesel and gasoline storage tanks in back of the physical plant that could be designated for biodiesel storage.

Magnitude of Potential GHG Reduction

In switching the college's diesel fleet to biodiesel there is a potential emissions reduction of about 440 MTCDE annually. This potential reduction is estimated based on the replacement of all 71,520 gallons of diesel consumed by the college annually. For every gallon of diesel fuel consumed 0.012265 MTCDE emissions are released; for every gallon of biodiesel consumed half of these CDE emissions are released, or 0.0061325 MTCDE.

In the winter, biodiesel does have a tendency to gel if not mixed with diesel fuel. A ratio of 20% biodiesel to 80% diesel fuel has proven to withstand the coldest of temperatures as far north as Alaska. Under these stipulations the overall potential CDE impact would be considerably lower. However, using other optional modifications of the diesel engine, it would be possible to burn biodiesel year round, regardless of temperature. (Although these modifications were not considered in our strategy, they would cost approximately $500 per vehicle.)

Benefits and Costs

Fixed Cost

We estimate that the startup costs associated with this strategy, in terms of staff time, would be about $5000. Storage facilities for biodiesel are already in place.

Variable Cost or Benefit

Dog River provides biodiesel at a cost of $1.30/gallon and delivers it in 55-gallon drums. At a cost of $0.58/gallon higher than what is currently paid for diesel fuel, this would soon add up to be a relatively expensive strategy for reducing CDE emissions. Based on the current level of 71,520 gallons of diesel consumed by the college, this would entail annual variable costs of $41,482. (In addition to the costs associated with converting to biodiesel (<$0.58/gallon) from diesel fuel, there would exist additional costs associated with having the fuel delivered from Dog River or another biodiesel provider.)

However, the company heads of Dog River have informed the college that they would be willing to provide biodiesel for Middlebury College at a significantly lower price. In addition, Middlebury College currently produces a waste stream of used vegetable oil of about 200 gallons each week or roughly 10,000 gallons annually. This used fryer grease can be easily processed into biodiesel for vehicle consumption, thus eliminating a waste stream and reducing the overall amount of purchased fuel.

Other Costs and Benefits

As mentioned above, there are issues associated with trying to burn straight biodiesel fuel in the coldest months of winter. However, there are many additional benefits to converting to biodiesel. Biodiesel is a non-toxic, non-corrosive, non-combustible, non-volatile fuel. Biodiesel has a higher viscosity when it is injected into the engine, and thus acts as a far better lubricant than conventional synthetic diesel fuel. As such, it reduces the overall noise of the engine, and tends generally to extend the overall life of the engine. Biodiesel provides equivalent miles to the gallon to synthetic diesel with equivalent horsepower and acceleration performance as well.

Perhaps the greatest benefit associated with switching to biodiesel fuel is the social and economic changes it supports within the state and country. The potential now exists for a community to grow its own fuel for consumption providing a radical alternative to paying corporations while disrupting the fragile geological cycle. The possibility for fuel creation and consumption to become more localized is also an exciting one, perhaps one day making oil drilling, tanker trucks filling highways, and disastrous oil spills a thing of the past. Middlebury has the opportunity within this strategy to set the tone for other colleges and universities to follow. The potential for biofuels is a great one, particularly in the state of Vermont with its partially agriculturally based economy.

Possible Financing Mechanisms

Possible financing mechanisms include pre-existing environmental grants, potential alumni financing pinpointed toward biodiesel efforts, funds collected from campus wide vehicle emissions tax. Local, state, and federal grants may even be worth looking into and applying for. In all likelihood the fuel prices associated with gasoline and diesel fuel will be rising in the coming years, thus reducing the price margin between biofuel and synthetic petroleum fuel. There exists the possibility to establish an on campus biodiesel processing area (Bicentennial Hall?) where an existing biodiesel processor could be operated to process the college's waste vegetable oil, and perhaps additional waste oil collected from local restaurants. Currently most restaurants pay over one hundred dollars each month to dispose of their generated waste oil.

Stakeholders

On campus

Purchasing department, campus administrators, CRI, Dining Services, organic garden personnel, stockroom personnel, Diesel vehicle users (Facilities Management, food services, recycling center, earthworks, Snow Bowl, golf course, general services, Nordic program, grounds crew, Breadloaf, heating plant)

Off campus

Local biodiesel providers (i.e. Dog River), current diesel fuel provider, diesel vehicle manufacturers, town officials, local restaurateurs

Examples from elsewhere

Other Colleges and Universities

-UVM runs in its campus fleet 9 buses on biodiesel.

-Middlebury college currently has one riding lawn mower tractor converted to run on straight vegetable oil.

-Middlebury currently has one student running his vehicle on straight vegetable oil and another running his vehicle on biodiesel with others looking to soon.

Other Institutions

-Green Mountain coffee has recently committed to biodiesel in all of its delivery vans.

-Fort McCoy Military Base ran 4 trucks on 20% biodiesel for over 50,000 miles.

Getting Started

The first people to contact to get this initiative going would be on campus diesel vehicle drivers to gain a general sense of their usage patterns. The next step would be to talk directly with the University of Vermont regarding their biodiesel buses. It would then make sense to talk over generally with dining services and perhaps some of the higher-ups within the chemistry department as to allocating space to process and store our own biodiesel produced on campus. It would then be very helpful and give us a general feel for how and when this could really start happening if we were able to sit down with some of the folks from Dog River Alternative Fuels.

IV.3.3.b – Encourage chartered diesel buses to use bio-fuel

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
31	None	36	$ (233)

Middlebury College currently charters 104 diesel coach buses each year, the majority of which are through the Premier Coach Company, with whom the college has established a contract. As previously mentioned, all diesel vehicles have the potential to run on biodiesel, and thus we are proposing as a possible strategy that the college negotiate with the Premier Coach Company the opportunity to run the college athletic travel on biodiesel.

Timeline

Middlebury College could begin negotiations with Premier Coach and a local biodiesel provider within the year and could be making biodiesel fueled trips to games and contests by the fall term of '03-'04. If there is applause and encouragement associated with the switch the college might consider purchasing some of its own coach buses to run on biodiesel in the next few years.

Magnitude of Potential GHG Reduction

Currently Middlebury College athletics teams travel over 35,000 miles each year to over 53 different locations in the Northeast. These trips account for an emissions figure close to 72 MTCDE annually. With enough convincing and financing with the coach company this figure could be cut in half, so that the magnitude of this potential emissions reduction would be on the order of 36 MTCDE annually.

This assumes that the buses made each trip on 100% biodiesel. In cases of extreme cold weather, the biodiesel would have to be mixed in a ratio of 20% biodiesel to 80% diesel fuel, thus reducing the overall estimated annual CDE emissions reduction. However, were any of these buses to be modified to run on straight vegetable oil (w/ a separate heated tank), they could burn vegetable oil straight through the winter without having to mix it with diesel, thus holding this estimate true.

Benefits and Costs

Fixed Cost

The startup costs associated with this strategy are very much dependant upon the Premier Coach Company's willingness to enter into a contract with the college regarding the use of biodiesel. This may or may not require a certain cost associated with creating an incentive for the bus company, although their willingness may be spurred by the publicity and general image it would create and market for them. As with the previous strategy, we assume that this would entail about $5000 in staff time.

Variable Cost or Benefit

The operating costs associated with this strategy would be dependant upon the general price discrepancies that now exist between diesel and biodiesel in the fuel market. Currently biodiesel can be purchased for $1.30 per gallon, $0.58 cents more expensive than conventional diesel fuel sold for $0.70 per gallon. With approximately 5,830 gallons of fuel being consumed by chartered buses on athletic trips in a given academic year, the overall price difference would be approximately $3,380 more to run on biodiesel. These operating costs would be reduced once a clear contract for a large enough order of biodiesel was established with a local provider. Also, it is possible that a portion of our campus -- and perhaps local restaurants -- vegetable oil waste streams could be processed into biodiesel, thereby offset the total number of gallons of purchases biodiesel.

Other Costs and Benefits

As detailed in the previous sub-section, the greatest benefits associated with switching to biodiesel fuel are the social and economic changes it supports within the state and country.

Possible Financing Mechanisms

As detailed in the previous sub-section, possible financing mechanisms include pre-existing environmental grants, potential alumni financing pinpointed toward biodiesel efforts, funds collected from a campus-wide vehicle emissions tax. Local, state, and federal grants may even be worth looking into and applying for.

Stakeholders

On campus

-Athletic teams, purchasing department, campus administrators, CRI, dining services, organic garden personnel, stockroom personnel

Off campus

- Premier Coach Company, other charter bus companies (Bristol tours, Avis, Hertz, etc.), coach bus manufacturers, Local biodiesel providers (i.e. Dog River), current diesel fuel provider, diesel vehicle manufacturers, town officials, local restaurateurs

Examples from elsewhere

Other Colleges and Universities

-UVM runs in its campus fleet 9 buses on biodiesel.

-In 1999 the Deer Valley School District in Phoenix, Arizona began to fuel a fleet of over 100 school buses with 20% biodiesel.

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Other Institutions

-City buses in Lincoln, Nebraska run on 25% biodiesel made from soybean oil.

-Biodiesel was used in Chicago's buses during the 1996 Democratic National Convention

Getting Started

-The first people to contact to get this initiative going would be the athletic teams as well as the Premier Coach Company (1-800-532-1811). The next step would be to talk directly with the University of Vermont regarding their biodiesel buses. It would then make sense to talk over generally with Dining Services and perhaps the Chemistry Department about allocating space to process and store our own biodiesel produced on campus. It would then be very helpful and give us a general feel for how and when this could really start happening if we were able to sit down with some of the folks from Dog River Alternative Fuels in conjunction with meeting with the Premier Coach people.

IV.3.4 Develop alternative transportation options and promote use

Summary of Strategies

a. Establish student shuttles at start, breaks, and close of each semester (airports, metropolitan centers). Establish weekend shuttles (Boston, Burlington, Montreal, etc.)

b. Collaborate with ACTR to provide daily commuting and other transportation needs

IV.3.4.a – Establish Student Shuttles at start, breaks* and close of each semester (airports, metropolitan areas) and on weekends* (Burlington, Boston, Montreal) (*note 4)

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
37	None	250	$ (78)

This strategy would be necessary in conjunction with a policy banning Freshmen and Sophomore vehicles on campus to assist and replace current commuting and entertainment trips made by students on a weekly and per-semester basis. This program could considerably reduce CDE emissions arising from parents dropping students off and picking them up from school. Simply banning student vehicles would be ineffective in reducing CDE without providing mass transportation alternatives. Because shuttles are fuel-inefficient, this strategy would not work without high ridership/participation. Hopefully, Juniors and Seniors would also participate in shuttle use, thereby contributing to fewer vehicles on campus and reduced VMT. This strategy is great because students pay the costs and the more students participating, the lower the costs. One component of this strategy would do the following: we could charter 2 buses from Premier Coach: a 56 person bus with stops in Hartford, CT and New York City, NY; and a 36 person bus with stops in Manchester, NH and Boston, MA. Each bus would be chartered at the beginning and end of each semester, and make trips at the beginning and ends of Fall Break, Thanksgiving and Spring Break (12 one-way trips per bus: 24 total). For future consideration, it may be preferable for the College to purchase buses and run them on biofuel!

Timeline

Could start immediately and could potentially be a permanent and valuable resource for the campus community. This strategy may be ineffective without limiting total number of student vehicles. Current shuttle program to the Burlington airport has been extremely successful. Chartering buses initially could be done to gauge student interest it may very well be feasible that there is even greater need and demand for such a service. The great thing about this strategy is its simplicity and flexibility. All that is necessary is signing up students and renting buses based on the number of interested students.

Magnitude of Potential GHG Reduction

▪ Charter Buses at the beginning/end of semesters and for Fall, Spring and Thanksgiving breaks: (see Appendix 1 for calculations)

Taking the average number of first-year students (2000 and 2001 incoming classes) from CT (average total students: 53), MA (avg. tot. students: 86), NH (15), NJ (40), NY (90) and PA (19), I made the assumption that a bus that went through Manchester, NH and ended in Boston, MA could shuttle approximately one-third the average number of first-year students from these states; and that another bus stopping in Hartford, CT and then ending in New York City, NY could transport approximately one-third of the average number of incoming Freshman from CT, NJ, NY, PA most of the way home. I came up with the following calculations: 1) One charter bus with 36-person capacity to Boston, through Manchester would cost around $1,000 ($28 per person). Given that the bus were full to capacity with 30 students from MA and 6 from NH, we could potentially eliminate 38 MTCDE and 432 individual vehicle trips (see Appendix 1A for calculations). 2) One 56-passenger bus to Hartford, CT and NYC would cost about $1,700 ($30 per student) and (given 13 CT students, NJ (10), NY (28), PA (5): Total 56) would eliminated 86 MTCDE and 660 individual trips (see Appendix 1B for calculations). Combined, the 2 buses (operating at full capacity) would eliminate 124 MTCDE and 1,092 individual trips. This option could be expanded to other areas and to include more students and bus trips based on perceived demand.

▪ Rental shuttles to Burlington, Montreal and Boston on the weekends:

Shuttles to Burlington, Montreal and Boston on the weekends could have a potentially higher CDE reduction impact than buses to Boston and NYC because of the frequency with which students make these trips. The following is a hypothetical situation: given that 30 cars drive to Burlington, 20 cars to Boston and 10 to Montreal every weekend during the academic year- the associated CDE emissions would be 30+ 140+ 60= ~230 MTCDE/year (see Appendix 2 for calculations) Assuming that shuttles on weekends could cut down this figure by at least 50%, there would be around 115 MTCDE reduced/year. Based on these estimated figures we would recommend chartering 36-person buses to Burlington and Boston on a regular basis (responsive to student demand) and perhaps monthly to Montreal. A 36-person charter bus to Burlington is approximately $700 round-trip ($20/student). Because of this relatively high cost, we would recommend that the College subsidize up to $13/student, or $468/per bus. If this shuttle were to run twice a month to Burlington, 6 months/year, costs would be around $5,600/year. A 36-person Boston round-trip once a month would cost $2,000 per round-trip ($56/student). Once again we would recommend that the College subsidize this cost up to $36/student ($1,296/round-trip), six times a year= around $7,800/year. If this strategy is pursued in conjunction with limiting the number of student vehicles on campus and other strategies that reduce the need for student vehicles, the College will ultimately save on the construction and maintenance of parking facilities, in addition to the social benefits associated with less student driving.

Stakeholders

On campus

Students, SGA, CCAL, Purchasing, Administration

Off campus

Transit providers- Premier Coach (current provider), ACTR, Middlebury Transit, parents of students.

Benefits and Costs

Fixed Cost

The College would have to pay someone to organize the shuttle service and schedule/reserve vehicles. We estimate that this would be about $5,000/year.

Variable Cost or Benefit

Students would share costs and the College pays a student worker to organize and schedule trips. Students would pay a flat rate for the service, and the College would subsidize the service. College subsidies for weekend travel to Burlington and Boston might be around $13,400/year. If we assume organization costs of $1,000/year, this would be 14,400/year for weekend shuttles.

Other Costs and Benefits

Social. Numerous shuttles to various sites of student interest would greatly enhance public interaction of students that might not otherwise spend time together. Riding on buses/shuttles allows students to relax during travel and enjoy themselves more than they would if they were concentrating on driving. Driving, in general, contributes to anxiety and stress, particularly if students are borrowing a friend's car. Having a safe/reliable shuttle to Burlington, Boston and other areas of interests on a more regular basis could improve students' overall well being and reduce the number of accidents that occur every year.

Public Relations. Shuttle and mass transportation options for students extend the public outreach of the College. Increased transportation options would enhance the attractiveness of our institution for all prospective students, particularly students from lower-income family backgrounds. We recommend discussing the impact of and potential PR benefits of this strategy with Leroy Nesbitt at the College's Office of Institutional Diversity and Advancement.

Cross-cutting synergies. UVM has 9 biofuel buses. If we could use biofuel buses to transport students around New England it would be a huge public statement and garner a lot of attention for our cause.

Possible Financing Mechanisms

Generally self-financing: students pay most of the costs.

Getting Started

Survey more students to get an accurate count of potential ridership. Interest in this type of program may be even higher than anticipated. Contact Bob Young at Premier Coach to set up.

IV.3.4.b – Collaborate with ACTR to provide daily commuting and other transportation needs.

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
19	None	150	$ (10)

Over the summer of 2002, Addison County Transit Resource (ACTR) updated its routes and schedules to better serve the needs of Addison County, particularly the residents of Vergennes, Bristol and Middlebury. ACTR currently operates two major shuttle services (the In-town Middlebury shuttle and the Tri-town shuttle [Vergennes-Bristol-Middlebury]) both of which have no ridership costs (i.e.- they're FREE to the public!!). The In-town Middlebury shuttle makes regular stops at several convenient College locations (Adirondack Circle, Old Chapel, McCullough and the CFA). The Tri-town shuttle brings commuters into Downtown Middlebury, where riders can easily transfer to the In-town shuttle or walk or bike from downtown to the College without having the hassle of sitting in traffic or finding a parking spot. As of FY 2001, there were approximately 500 faculty/staff residing in Middlebury (accounting for 240,000 commuting miles per year), 57 in Bristol (465,000 VMT) and 38 in Vergennes (237,000 VMT). These individuals already have a no-cost commuting option available to them. Lack of awareness of this resource and its routes/schedules as well as individual transportation needs (child care) are the current major barriers to greater public transportation use. In prior years (before the route/scheduling changes were in effect) the service was inconvenient because of its infrequent and meandering route. It is reasonable to encourage use of this resource and to expect significant ridership if proper incentives (parking rebates) were offered in addition to the added benefits of personal savings (reduced spending on gas, 15% car insurance reduction, less wear-and-tear on the car, lowered associated maintenance costs, reduced accident potential, less stress and anxiety associated with commuting, etc.).

Timeline

In conjunction with the proposed parking rebate and registration fee, this strategy could be up and running for limited cost beginning immediately. Collaboration with ACTR could begin in the next 5-10 years to expand its services to other towns.

Magnitude of Potential GHG Reduction

Having outlined the numerous benefits of the new and improved public shuttle option, we feel that is it reasonable to assume at least a 20% participation rate for those individuals living in Middlebury, Bristol and Vergennes (given that the parking rebate strategy was simultaneously implemented). VMT associated with faculty/staff commuting from these towns in FY 2001 was 942,000 (942,000 divided by 25mpg= 37,600 gallons x .013 MTCDE/gallon = 492 MTCDE. A 20% reduction would be 98 MTCDE; 10% reduction: 49 MTCDE and in an ideal future scenario of 50%: 246 MTCDE). These potential reduction figures assume that ACTR does not expand its service to other towns in the future. If the College promotes usage and collaborates with ACTR to provide greater service to more communities, the Magnitude of Potential GHG Reduction could be even higher (not just for the College but for the entire county). For this reason, we feel that promoting use of and expansion of ACTR could- in the long-term- be one of the most valuable strategies- given the social, environmental and PR benefits. Investing in ACTR could also be considered a CDE offset! If ACTR expanded to serve all major town centers in the County, the associated CDE reduction (given 10% reduction in estimated FY 2001faculty/staff commuting of around 6,000,000 VMT) would be around 3,100 MTCDE! And that is if we only counted the reduction in commuting, not to mention the potential reduction associated with other activities.

Benefits and Costs

Fixed Cost

In theory, startup costs would be modest - simply getting the word out and distributing schedules, routes, etc. However, in order to be effective, the College would have to improve on-campus bus stops by adding pavement, benches, shelters, etc. If we were to commit to a longer-term partnership, we would want to invest in similar structural improvements in town and in other towns that may be potentially serviced by ACTR. We estimate about $5000 in staff time for these activities.

Variable Cost or Benefit

If a partnership were set up, ACTR would manage most of costs, while the College could contribute to expansion and improvement projects. We estimate an annual cost of $1000 in staff time for maintaining this program.

Other Costs and Benefits

Social. Because of its cultural character, this issue and strategy has a potentially higher social impact than any other strategy in this entire report. Mass transportation and public transportation (as a principle) are at odds with pop culture American values- at least that is the light in which public transportation has been portrayed. We would argue instead that balanced transportation is much more beneficial to society as a whole because it provides greater freedom and choice than car-dependency. Notice: balanced transportation does not mean "no cars," it simply means that- for example- if you choose not to spend your morning sitting in traffic and paying for gasoline, you should have alternatives available for commuting. Public transportation is more costly in rural areas (and in Vermont, especially) than in cities because of the lower population densities; however, that does not mean that it should be written off altogether. In big cities, personal cars are unnecessary because of increased location efficiency.

This is not the case in Vermont- we need cars for transportation. The goal of promoting public transportation and alternative options is to reduce VMT and to offer choice to those for whom commuting by shuttle is an option and for those members of our community that are "transportation-challenged" (kids, elderly, poor, college students without cars, etc.). Currently, the average U.S. household spends around 20% of their income on transportation costs, this figure is reduced considerably in areas with public transportation where individuals can save money on all the associated costs of car-dependency and avoid the health risks and environmental degradation that accompany car-oriented development and lifestyles.

Public Relations. It would look great if the College promoted public transportation in the County and made it a viable, attractive option.

Stakeholders

On campus

Faculty/staff would be the key stakeholders for this strategy. Raising awareness would be relatively simple- letters to all faculty/staff explaining the service, the associated benefits and including a printed schedule and contact information for further questions (Jim Moulton: ACTR Executive Director). Improvements to the College bus stops would be crucial to this strategy. We would need to have facilities maintenance construct small shelters, install benches, pave standing areas and keep them clear during the winter.

Off campus

Addison Country Transit Resource (ACTR); Contact: Jim Moulton. Towns of Middlebury, Bristol, Vergennes would have to find funding to improve the convenience and visibility of bus stops in addition to increasing general awareness.

Getting Started

We need to establish a permanent relationship between Middlebury and ACTR. Jim Moulton is a new Director and he is very approachable and flexible. He was willing to adapt to meet College need and designed new routes and schedules over the summer with potential College riders in mind. We need to continually assess and gauge College transportation needs that could be met by public transportation. Instead of complaining about the "empty" shuttle we can participate in the expansion of ACTR's efforts to ensure its relevance and usefulness to the College community. Commons Councils and First-year orientation planners should design ways to get the word out and to educate in-coming students of shuttle stops, routes and schedules. Requesting and distributing schedules to all faculty/staff would also be a great first step.

IV.4 Future Considerations

IV.4.1 – Discouraging faculty/staff/students from using high emissions producing, fuel inefficient vehicles

This strategy would implement a fee-based system in which a specific allowed vehicle emissions criteria would be established and all those not meeting the specified standard would be required to pay the price of offsetting their CDE emissions difference. Those meeting the strict emissions standard would pay nothing and those reducing their emissions below the allowed figure would be given green parking stickers that would entitle them to park their vehicle in designated parking spaces located in prime locations of various campus lots. In addition to reducing the overall CDE emissions footprint of the college, the funds collected would produce a positive monetary gain to be allocated for more costly strategies. This would encourage information and technology sharing between faculty, staff, and students regarding cleaner vehicles, and would serve to encourage us all to begin thinking of our individual CDE emissions contribution. This system would encourage those considering vehicle transportation to and from campus to investigate the options associated with cleaner and more energy efficient vehicles. Carbon neutrality is a worldwide issue, however, lifestyle changes must occur on the individual level for any of us to witness a significant change.

Timeline

This strategy could be established and agreed upon by administrators within the year and implemented within the next year or two. Those not meeting the emissions criteria would pay a graduated annual fee that would correspond to the degree to which they exceeded the CDE emissions limits. It would be proposed that as the years passed and increasingly more faculty, staff, and students would be reaching well below the allowed emissions with their personal vehicles, that the entire scale of cost penalties be adjusted for an even stricter standard of allowed vehicle emissions. The lifetime of this strategy would carry well into the next 5-10 years upon its date of implementation as we will still see individuals still producing emissions from vehicle transportation, yet we will witness vehicle technology continue to grow to become increasingly cleaner and energy efficient as well as more readily available to the general public.

Magnitude of Potential GHG Reduction

Assuming that each student, faculty, and staff member of the college drove 5,000 miles annually in their gasoline vehicle (each vehicle getting an average of 25 mpg), each would personally be responsible for 2.6 MTCDE emissions going into the atmosphere. Though this only an estimate, it shows how daunting the emissions from individual automobile travel can be. There is no accurate way of determining what kind of overall CDE reduction this strategy might induce as it is greatly dependent on how great a fee each of us would put up with before we acted directly to change our modes of transportation. It would certainly be on the order of tens, perhaps hundreds of MTCDE reduced annually. The growth of the overall CDE reduction would certainly be accentuated as the CDE fees grew higher and less affordable to the college community.

Benefits and Costs

Fixed Cost

The startup cost associated with this strategy would be relatively minimal, requiring merely notification to the college community of its implementation, printing and issuing of green stickers accordingly by the public safety department as students, faculty, and staff register their vehicles. There would be a small cost associated with purchasing and installing signs designating "green parking areas."

Variable Cost or Benefit

There would be no operational costs associated with this strategy. Public safety personnel would perhaps be issuing more parking tickets as there would most probably be some violation of the "green parking areas" by drivers of non-green vehicles, but this would not cause them to have to deviate from the current protocol.

Other Costs and Benefits

There would be many social benefits of this strategy in addition to the large sums that would inevitably collected from establishing this fee system to go towards other initiatives to make Middlebury College carbon neutral. Such a system of fees would send a strong and important message to the town and surrounding area as well as other colleges and universities that Middlebury College is directly confronting its CDE emissions head on and is willing to address to the excessiveness of modern driving habits. The strategy would serve to greatly improve Middlebury College's environmental image in the country and around the world. There is a great benefit associated with the ease with which this strategy could be implemented and the relatively high potential CDE emissions reduction at very minimal costs.

Possible Financing Mechanisms

Public Safety could feasibly budget for the necessary parking stickers associated with this strategy and the payback would be immediate upon collection of the CDE emissions taxes.

Stakeholders

On campus

These would include all faculty, staff, and students owning and operating personal vehicles. In addition Public Safety would be directly involved and the CRI would receive the funds collected and allocate them where appropriate.

Off campus

Vehicle manufactures, fuel providers.

Getting Started

It would be helpful to discuss and organize how and when this strategy could be implemented amongst the members of the on campus CRI committee. It would then be necessary to present idea through to the administration. Education of the college community would be the first big step toward informing the population of the necessary reasons for implementing this program. Once it is confirmed to take effect at the start of any given school year, Public Safety would need to inform and communicate the protocol for issuing stickers and collecting fees.

IV.4.2 – Invest in bicycle/pedestrian and multi/modal infrastructure

This strategy entails adding numerous bike and footpaths, curb cuts, bike racks, bike storage and maintenance facilities and locker/shower facilities, as well as installing traffic calming devices such as raised crosswalks, stop signs, extended curbs and others. The two major state highways (Rtes 30 and 125) cutting through the heart of the campus serve as major barriers for North/South traffic flow. We recommend countering this effect with two "bike-pedestrian highways" from Bicentennial Hall to the CFA/Sports Center that create a north-south "fertile crescent" between them (see Appendix 2 for the written proposal submitted to the SGA). We also recommend creating bike lanes on Rte 30 from Downtown Middlebury to Cornwall and promoting an additional in-town bike-pedestrian bridge similar to the one that connects Frog Hollow and Marble Works (see Appendix 3 for proposal). These strategies will entail cooperation with the Town Planner and Select Board and offer a great opportunity to cooperate on projects that both the Town and College could benefit from. To improve access to the High School we recommend creating a bike path from South St (Middlebury College baseball field) to the Otter Creek Footbridge behind the High School as well as a small pick-up/drop-off area on South St. close to the path leading to the Footbridge where parents can pick-up/drop-off their kids before and after school without having to go through downtown Middlebury. For employee commuting, we should investigate using already existing peripheral parking lots (Ames Plaza and North on Exchange St) as park & go facilities. We would have to make some upgrades to the lots (overnight bike storage and bus shelters) so that multiple transportation modes could be utilized. Imagine someone commuting north or south on Rte 7, parking at a peripheral parking lot and then walking, biking, sharing a ride or taking the shuttle through town to the College. This strategy would reduce overall emissions, reduce the number of vehicles on campus (and therefore parking spaces needed on campus), reduce traffic downtown, improve air quality and aesthetics downtown, and make roads safer for kids and others to bike and walk. (See note 3 below for more in-depth discussion of a peripheral park and shuttle system.)[3]

Timeline

Planning and constructing the two bike/foot pathways could be completed in a year and a half. The first year would involve planning and getting student and employee feedback; construction would take place the next year. Consideration of this proposal is important in the short-term because of the plans to close Old Chapel Road to cars. Plans for doing so should be coordinated with the bike/foot highways so that they connect. Other projects, such as bike paths on Rte 30, in-town bike/foot bridge by Mr. Ups and the High School connector path and pick-up/drop-off area should be discussed with the Town and pursued from that point.

Other Costs and Benefits

Encouraging less car use on campus would reduce the time and resources spent in the permitting and construction of parking lots as well as (from the Public Safety side) monitoring.

For a greater discussion of benefits of a pedestrian-friendly campus, see the report from Spring 2002 “Redefining the Pedestrian Campus.”

Getting Started

Plan a meeting with SGA representatives, members of the Master Planning group, a representative from Facilities Planning, Ben Brouwer (Yellow Bikes Program) and others. This meeting should be open to the public to get feedback on these proposals and other possible transportation oriented solutions to traffic, car-dependency and lack of alternative infrastructure on campus and in town. Hopefully this could jump start a working group dedicated to these (and other necessary) projects for improving our natural and human environment.

IV.4.3 – Other future considerations

1 Telecommuting:

What if all faculty/staff commuted one less day a week and worked from home on the Internet or over the phone? The potential CDE savings would be huge: [one fifth of FY 2003 estimated faculty/staff commuting (around 3,000 MTCDE)= 600 MTCDE/year]. Clearly this is not an option for many College employees, but the idea is so crazy, it just might work. Why not reduce the work week? Employees may be more productive- something to investigate.

2 Provide Day Care & Kid Transportation:

Talking with College employees, we found that the issue of transporting children to and from school and day care tends to be the number one objection to opting for alternative commuting methods. Rather than giving up, we should pool our resources and efforts as a community to tackle this issue head on. What is wrong with the current public school bus system? Why aren’t our kids safe traveling to school alone? Why can’t the day care centers provide transportation? All of these questions have answers and solutions. We recommend conducting a survey that identifies the transportation needs of faculty/staff and creating an ad hoc committee to come up with some creative solutions for them. Why can’t we pay College students to pick up kids from school and take them to after school programs and/or back to campus? We would definitely save a lot of individual car trips! If we address these problems as a community and are committed to reducing our VMT, we have the opportunity to navigate uncharted territory and set a precedent for other institutions. If we improve pedestrian and bike paths, increase the number of crosswalks and stop signs and implement traffic calming measures, we would be designing our neighborhoods to facilitate greater independence, safety and mobility for our children and ourselves.

3 Increase Availability/Affordability of Local Housing:

Our car-oriented lifestyles are ultimately dictated by the location of our homes, which tend to be far from work and grocery stores (especially in Vermont). The best way to reduce commuting emissions is to provide more affordable housing units in Middlebury; thereby eliminating the “necessity” of individual car commutes. This is a long-term and politically charged strategy with even greater social, economic and environmental benefits for individuals. Just imagine the savings on car costs associated with not having to commute by car!

4 Fuel-efficient landscaping:

So far, we've talked about ways to reduce driving and switching to cleaner fuels. How about changing the look and feel of our campus grounds? Promoting the natural growth of local vegetation in strategic locations could reduce the need for lawn care (mowers, trimmers, etc.) and could provide an educational opportunity for students.

5 "Pedestrian-friendly" campus:

Defining and investing in a "pedestrian-friendly" campus is a comprehensive objective with numerous environmental and social benefits. All of the other strategies that have been detailed in the Transportation section are part of this larger objective. Ultimately, "pedestrian-friendly" is about creating an environment on-campus, in-town and in the region that supports transportation choice and promotes alternatives to single-occupancy vehicles. For the purposes of thinking about transportation in a more over-arching way, we recommend reading the ES401 class report "Redefining the Pedestrian Campus" and other associated materials included in the appendices and notes of this section. The first objective is to institutionalize balanced transportation planning principles into our planning processes and our administrative apparatus- (Master Plan, Commons development, Facilities Planning, CRI working group, Community Council, Executive Council, Environmental Council, Student Orientation, Admissions, etc.). The Transportation Subcommittee of the Environmental Council is currently addressing some of these issues.

6 Bring Back the Train!

Have you ever wondered how students used to get to Middlebury College before they all had cars? Well, as a matter of fact, many traveled to and from Middlebury by train. We still have an active rail line through town and members of the Town planning board and the ACRPC have been investigating renovating the old train station in hopes that passenger trains will return to Middlebury. If we could somehow get a regular train through Middlebury to Burlington and down to Rutland, we would once again be connected to the rest of the country without having to own a car.

IV.5 References and Notes

1. This idealistic conclusion and portrait of a "pedestrian-friendly" and more community-oriented campus will not be achieved simply by banning freshman and sophomore cars; rather, only a strong institutional commitment to developing new transportation options and promoting and educating students of these alternatives will achieve the end-goals of carbon neutrality and an attractive, accessible "pedestrian-campus." Our current inability to provide alternatives for student transportation needs leaves no other option but our current car-friendly policy. In a larger context of global environmental and social responsibility, insisting on car-dependency for all is not- as some may claim- a wise or principled choice. Banning first-year car use will be a tough choice to make but in the

years to come, if we are willing to make the necessary commitment to expanding our transportation choices, it will clearly be the correct choice

2. Department of Public Safety figures (avg. of last five years).

3. *PARK & RIDE PROPOSAL:*

Middlebury is a regional hub. While only 8,000 people live in the Town itself, many of Addison County's residents depend on Middlebury for services and shopping. 70% of the traffic generated in the Town begins or ends in Middlebury and is generated by individuals coming from both inside and outside of Town (Middlebury Town Plan). Contrary to popular belief, through-traffic makes up only a portion of the downtown traffic problems. The proposed Rte 7 bypass will not solve the traffic and air/noise pollution problems. Shuttles, walking and biking are not feasible options for the majority of commuters in the area because of the great distances, lack of options and infrastructure, and because of poor weather conditions in the winter. The key seems to be 1) reducing the number of trips that are necessary and 2) reducing the distances driven.

- *Traffic Congestion:*

For most of us, traffic congestion is the most visible symptom of car-dependency and the problems that it entails. If for no other reason, the issue of reducing traffic volume should be tackled in order to make streets safer and less congested for all users: pedestrians, bicyclists and automobile-operators.

- *Road Maintenance Costs:*

Money for alternative transportation in Middlebury is non-existent. This is due, in part, to the assumption that non-motorized traffic is unreliable and unimportant. But, more importantly, our assumptions and attitudes dictate the allocation of resources. There simply is no funding for alternative transportation and therefore there is no chance for behavior and infrastructure to transform to meet the needs of a diverse population with diverse needs. Road maintenance is a priority because the roads receive so much wear and tear. What if there weren't so many cars driving around downtown Middlebury? The cost of maintaining the roads would be manageable and money could be saved for reallocation to alternative transportation that keeps motor-vehicle volumes at a minimum.

- *Downtown vitality:*

Traffic congestion, pollution and parking crunches all combine to make Middlebury less attractive to visit. The solution is not more parking lots but rather the creation of a human friendly environment that is easily and comfortably accessible.

With these considerations in mind, what is a reasonable strategy to achieve reduced traffic volume and enhance community with limited costs and no additional infrastructure. Most transportation planning tries to get people from their homes to the places they need to go but clearly it is impossible to devise a public transportation system that reaches everyone's home; Middlebury's rural environment makes this virtually impossible. However, there are many portions of car trips that can be eliminated by creating park and ride facilities on the periphery of the town. Someone commuting from outside of town can park in an already existing parking lot (Ames, VFW, Beef supply, etc.) and catch the shuttle, bike, walk or car pool from that parking facility to their destination. This will achieve all of the goals that have been stated by the Town by reducing the downtown traffic and wear and tear on roads.

I recommend identifying commuter volumes by destination and origin and matching them with peripheral parking facilities that can be serviced by public shuttle: ACTR.

4. The offsets calculated for this strategy were not included in the original inventory by Doug Dagan. Any MTCDE saved by additional round-trips and weekend travel are new to the inventory.

IV.6 Appendices

IV.6.1: Chartering Buses to Boston and New York City

*(all mileages estimated by averages of 2000 and 2001 first-year class figures provided by Connie Bisson).

1A) Without 36-person bus to Manchester and Boston

[MA: (total mileage associated with all one round-trips for the avg. MA student: 35,000)] + [NH: ("" NH student: 4,300)]= 39,300 miles

39,300 miles x (6 round-trips a year per student {counting fall break, Thanksgiving, spring break) = 235,800 miles

235,800 miles/ 25 mpg x .013 tonnes CO2 per gallon = 123 tonnes

1B) With 36-person bus to Manchester and Boston making 12 trips/year:

MA: (mileage associated with # of MA students minus the 30 riding the bus: 407 x 56= 22,792 miles); 22,792 miles x 6 round-trip commutes/year= 136,752 miles/year

NH: (mileage associated with # of NH students minus the 6 riding the bus: 287 x 9= 2,583); 2,583 miles x 6 round-trip commutes/year= 15,498 miles.
(MA) 136,752 miles/year + (NH) 15,498= 152,250 miles/year; [(152,250 miles/year divided by 25 miles/gallon) x .013 tonnes CO2/gallon]= 80 tonnes of CO2.

Bus trips: 407(round-trip to Boston) x 6 round-trips= 2,442 miles/year; [(2,442 miles/year divided 6 miles/gallon= 407 gallons) x .013 tonnes= 5 tonnes C02/year.

Total CO2 associated MA and NH with 36-person bus:

80 tonnes (non-bus riders) + 5 tonnes (bus riders)= 85 tonnes total per year

1C) Without 56-person bus to Hartford, CT and NYC, NY

[(total mileage associated with all one round-trips for the avg. CT student: 20,000 miles) + ("" NJ student: 26,000 miles) + ("" NY student: 43,000 miles) + ("" PA student: 13,400)] = 102,400 miles/year; 102,400 miles/year x 6 round trips/year = 614,400 miles; 614,000 miles divided by 25 miles/gallon= 24,576 gallons

24,576 gallons/year x .013 tonnes CO2/gallon= 320 tonnes

1D) With 56-person bus to Hartford and New York City:

CT: (mileage associated with # of CT students minus the 13 riding the bus: 377miles x 40 students x 6 round trips= 90, 480); 90,480 divided by 25 miles per gallon= 3,619 gallons/year; 3,619 gallons/year x .013 tonnes= 47 tonnes CO2/year

NJ: (mileage associated with # of NJ students minus the 10 riding the bus: 650 miles x 30 students x 6 round trips= 117,000); 117,000 miles/year divided by 25 miles/gallon= 4,680; 4,680 gallons/year x .013 tonnes= 60 tonnes

NY: (“” NY students minus the 28 riding the bus: 478 miles x 62 students x 6 round trips= 177,816 miles/year); 177,816 miles/year divided by 25 miles/gallon= 7,112 gallons; 7,112 gallons x .013 tonnes CO2/gallon= 90 tonnes

PA: (“” PA students minus the 5 riding the bus: 705 miles x 14 students x 6 round-trips= 59,243 miles/year); 59,243 miles/year divided by 25 miles/gallon= 2,370 gallons/year; 2,370 gallons/year x .013 tonnes CO2/gallon= 30 tonnes

CT(47 tonnes)+ NJ(60 tonnes)+ NY(90 tonnes)+ PA(30 tonnes)= 227 tonnes

IV.6.2: Calculating CDE savings on weekend buses to Burlington, Boston and Montreal

(Burlington: 30 x 2[round-trip]= 60 x 35 miles= 2100 miles/week x 28 weeks= 58,800miles/year divided by 25 miles per gallon= 2,352 gallons of gas x .013 tonnes CO2/gallon of gas= 30 tonnes of CO2; Boston: 20 x 2= 40 x 240 miles= 9600 miles/week x 28 weeks= 268,800 miles/year divided by 25 miles per gallon= 10,752 gallons of gas x .013 tonnes CO2/gallon of gas= 140 tonnes of CO2; Montreal: 10 x 2= 20 x 200 miles= 4,000 miles/week x 28 weeks= 112,000 miles/year divided by 25 miles per gallon= 4,480 gallons of gas x .013 tonnes CO2/gallon of gas= 59 tonnes of CO2; TOTAL Boston + Burlington + Montreal= ~230 tonnes CO2/year).

IV.6.3: Facilitating Improved Bicycle-Pedestrian Circulation: Implementing the “Pedestrian Campus”

A collaborative report by: Gabe Epperson (’02.5) and the SGA Facilities Planning Committee

I. Introduction:

As long as driving is more convenient, more accessible and more acceptable it will remain the preferred mode of travel for all College members. The key to creating a “pedestrian campus” is connectivity- both in the physical infrastructure of the campus and in the campus planning and decision-making apparatus. This brief report represents the SGA Facilities Planning Committee’s recommendations for needed physical infrastructure improvements. Currently, pedestrian and bike routes are zigzagged and disjointed across campus. Circulation is relatively well-defined and fluid within different quads and sectors of the campus but not between the quads. In order to reduce car usage and increase non-motor travel, the paths on this campus must be better planned and coordinated. Our proposed solution includes two major bicycle-pedestrian “highways,” with feeder paths, along the “academic spine” and the “social spine” that connect the different regions of the campus across Rte 125 and Rte 30. These are already the major arteries of inner-campus circulation- this is common knowledge to students and was reaffirmed by the Wallace Floyd Design circulation study. These circulation paths must be given priority by installing crosswalks, sidewalks, bike lanes, curb cuts and signs where necessary. Motor vehicle traffic, roads and parking places fragment the campus and create barriers to a “pedestrian campus”- if we can eliminate these barriers, Middlebury College will be a safer, friendlier, more attractive place to live, work and visit.

II. Defining the *Academic* and *Social* "Spines:"

"*Academic Spine*"- For students and faculty, this is the major travel route during the school week: between classes, during lunch and running errands. This "spine" runs from Bicentennial Hall and FIC to the Chateau Quadrangle, crosses Rte 125 in front of Sunderland Media Center, travels down Old Chapel Rd to McCullough and continues between DKE and Centeno across Rte 30 to the CFA and the Sports Center.

"*Social Spine*"- In addition to serving many of the functions of the "academic spine" the "Social spine" is the major travel route for students throughout the week and on the weekends going to the fitness center, running errands, visiting friends, eating meals and more. The "social spine" also begins at Bicentennial Hall and FIC but arches towards the west, traveling east of Ross Commons and Pearsons and crossing Rte 125 towards Hepburn Road between Forrest and Adirondack. From Rte 125 it continues along Hepburn Road and down Stewart Hill, crossing Rte 30 to the CFA and the Sports Center.

III. Creating two Bicycle-Pedestrian "Highways" along the "Spines:"

A. General

New Buildings and Construction should occur within the context of the whole campus and the major pedestrian circulation routes. New paths should connect to the bicycle-pedestrian "highways." This applies to the new Library and the new Atwater Commons facility. Any project should be more than the building itself. New construction tends to attract traffic- accounting for these changing traffic patterns and establishing connections with the rest of the campus are critical steps.

B. Specific Locations for Immediate Action

1. Academic Spine

Students exiting from McCullough going towards the CFA and Sports Center have no clearly defined crosswalk or safe path. We recommend a raised crosswalk, pedestrian/bike signage, proper curb cuts and clearly defined bike lanes. On the north end of Old Chapel Road there is no convenient connection to the major bike route along the "academic spine." We recommend a clear and safe connection for bikes all the way from Bicentennial Hall to the north entrance of Old Chapel Road, including widening the major path that already exists with a specific surface designated as the bike lane that could go around the green between Battell and Johnson Memorial Art Building as a sort of one-way round-about. The Chateau Quadrangle should be redesigned as a public gathering space or square/plaza that combines the ideas of flow and interaction. The combination of the above-mentioned physical changes would create the type of continuous and accessible paths/networks that would facilitate improved and increased bi-ped traffic along the "academic spine."

2. Social Spine

New Ross Commons down to Ridgeline

There needs to be a clearly designated bike lane down the hill to the Ridgeline parking lot with a stop sign at the bottom so bikers and pedestrians coming from up the hill or Bicentennial Hall will feel safe crossing towards the parking lot. Currently there is no continuous sidewalk or bike path on the south side of College St/Rte125 from Ridgeline all the way to Warner. The new Ross Commons complex is a major destination for bikers and should have a designated path or entrance with convenient bike storage/bike racks for bikers traveling along the "social spine."

Hepburn Road

This road should be closed and narrowed for emergency use only. We recommend eliminating curbs and installing new bike-pedestrian permeable gates on either entrance (Rte 125 and Stewart). The gates should be easily opened for emergency access and maintenance as well as special events. The area between Proctor and Mead Chapel/Gifford/Hepburn should be a combined dining terrace, plaza and green area for socializing, eating and recreation. These changes would not exclude access and parking to events at Mead Chapel and Proctor. Instead the road width should be narrowed and the surface modified- perhaps brick or cobblestone with a bike lane contiguous to the prior mentioned "social spine" bike path. These changes would enhance mobility and encourage greater social interaction along paths and within outdoor gathering places, making biking and walking more attractive options. It is our hope that these bi-ped highways and improved infrastructure will transform this campus by creating a more vibrant and friendly atmosphere.

3. Rte 30

-Traffic calming measures, improved lighting, new sidewalks and crosswalks, and signs need to be added along Rte 30 as was done on Rte 125. Many students drive to the Sports Center because of the lack of bicycle-pedestrian infrastructure along Rte 30.

-Further, bike lanes on Rte 30 into town would encourage students and College employees to run errands by bike rather than by car. This may also be the major route for potential bike commuters coming from town or from Cornwall because of the shower facilities in the Sports Center and this is an easier route than College St to travel by bike because it is not as steep.

-The College should construct a direct path from the CFA parking lot to Old Chapel Rd along with proper bike facilities at the CFA parking lot for overnight storage. Many Faculty/Staff who park there may want to keep a bike on campus to get around; this would be an excellent place for them to store their bikes overnight.

Stewart Hill and the Rte 30 intersection:

-This intersection is a major deterrent to increased bicycle-pedestrian activity on campus, as it is a choke point for all traffic- motorized and non-motorized. We recommend limiting entrance and mobility of automobiles in this intersection. It doesn't have to be one-way, but cars from Rte 30 should not be able to enter here.

-The speed bump at the bottom of the hill is a bicycle hazard; a five- to six foot portion of it should be filled in for bicyclists.

-Put in crosswalks between Centeno and CFA, or a similar crosswalk as exists between Gifford/Proctor and Adirondack/Forrest.

-Cars coming down Stewart Hill and from the service building should be prevented from taking a right towards the Sports Center/Cornwall- this can be done by putting up a "no right turn" sign. This will deter students from driving to the fitness center as well as making the crosswalk safer for bikes and pedestrians.

IV. Conclusion:

The proposed campus improvements in this report are by no means the solution to the College's transportation problems. Student travel to and from Middlebury for the holidays or on weekends is predominantly by car because of our rural location and because of the lack of alternatives. Our top transportation planning priorities should be to improve accessibility and to enhance our travel options. The proposal to restrict freshmen from bringing cars is shortsighted and does not address the needs of our community. Do we really want students to feel more isolated than they already are? A combination of physical campus changes and an array of programs, such as a user-friendly on-line rideboard and a shuttle service to Burlington are the types of changes that will make a positive influence on our College environment. Only when students feel that they will not be trapped on campus once they arrive will they stop bringing their cars. And so what if students bring cars to campus? The problem is not the presence of cars but rather the unnecessary on-campus trips and trips into town that could be traveled by foot, bike or shuttle. We need to sit down together and start asking important questions such as- "what are our transportation needs?" and "how can we plan for meeting those needs without being dependent on automobiles?" The proposed "bi-ped highway" is a component of the larger solution that should include faculty/staff commuting research to promote alternatives and cooperation with the town and county on larger projects, such as park-and-ride facilities and bike paths that further connect communities and enhance the quality of our lives and Towns.

IV.6.4: Proposal for Multi-modal Facility at the Site of the Municipal Parking Lot Located Behind Ilsley Library and Mr. Ups

TO: Town of Middlebury Select Board

I. Proposal:

Phase 1 (1-2 years)

Begin construction of the parking terraces, as outlined in the Cross Street (In-Town) Bridge Plan, with the addition of a bicycle storage facility and an informational plaque/kiosk/board for visitors.

Construct a Pedestrian-Bicycle bridge that would run parallel to the proposed site of the Cross Street Bridge. This would be done in such a fashion as not to exclude the future construction of a motor-vehicle bridge, as proposed in the Cross Street Bridge Plan.

Phase 2 (3-5 years)

Purchase the Steele Auto-Service Building and transform it into the new ACTR Headquarters and bus storage station.

Phase 3 (5-10 years)

Begin construction of a motor-vehicle bridge at the proposed In-town location to Complement the already existing multi-modal, downtown transportation facility.

II. Reasons:

1. The above proposal would address many of the needs raised in the Middlebury Town Plan and the Cross Street (In-Town) Bridge Report (1992), such as- 1) providing for downtown access to businesses and services, 2) enhancing downtown vitality, 3) encouraging human scale development, 4) providing a safe alternative route for school children, town residents, students, visitors to cross the river and reach multiple downtown and Rt 7 destinations, 5) alleviate downtown traffic.

2. This proposal would allow for a phased process that would alleviate the financial burden of acquiring all of the funds at once. In addition, since this project would be conceptualized as a Multi-modal facility to

enhance transportation options for public transit users, bicycles and pedestrians, it would be much more likely to receive federal grants.

3. This proposal (if undertaken in cooperation with ACTR) would help to alleviate traffic congestion downtown (and on Battel Bridge) and reduce potential pedestrian-vehicle collisions by encouraging biking, walking and shuttle use. In addition, if traffic reduction could be achieved, the wear and tear on the roads and the policing burden that accompany large volumes of motorized traffic would also decrease, therefore valuable property tax money could be spent on other higher priorities than subsidizing automobile usage.

4. This proposal could bring considerable business benefits to restaurants in the vicinity and downtown retailers. Also, the proximity of the library makes pedestrian and bicycle friendly development all the more attractive. The library could be more accessible to children and the general public.

III. Recommendations:

I recommend that the Board of Selectmen appoint a task force to:

1. select a site for the pedestrian-bicycle bridge
2. solicit public feedback and build public support and awareness
3. work with the Regional Planning Commission to acquire funds for Phase 1
4. determine further needed actions

IV. Conclusion:

This is an opportune time to begin work on a long-term project that has shorter-term phases, all of which have potential to benefit the community's residents and the downtown district. The Town has needed a downtown alternative route for a long time and the Cross Street location was shown to be the most effective. I believe that this is an economical approach to achieve the goals stated and pursued in the study of an alternative In-Town Bridge. Hopefully, this proposal would meet with considerably less public resistance because of its smaller, human scale development process. Middlebury needs this project but has struggled with funding and support. This proposal may help to address the financial and community concerns of all of Middlebury's residents and will help fill the void of the Town's currently limited downtown transportation infrastructure.

V. Solid Waste

V.1 Greenhouse Gas Emitting Activities

The relevance of solid waste in this age of material inundation, planned obsolescence, and throwaway products is indeed unquestionable, whether discussing pop cans, fashion, or climate change. In its 2001 report, the Intergovernmental Panel on Climate Change outlined five ways in which solid waste affects GHG emissions[1]: (1) landfill emissions of methane; (2) reductions in fossil fuel use through energy recovery systems from waste combustion; (3) reductions in energy consumption and process gas releases in extractive and manufacturing industries as a result of source reduction and recycling; (4) emissions associated with the energy used in the transportation and processing of waste disposal or recycling; (5) and carbon sequestration in forests, as virgin lumber is replaced with recycled material. However, while this list is helpful in conceptualizing solid waste's climate change impact, defining GHG emissions associated with solid waste is nevertheless an arduous and complex task. Indeed, as Lester Brown wrote, "The scale of the materials economy is far larger than most of us ever imagine, simply because we come in contact with only the final product – we see, for example, the paper in our newspapers…but not the stack of logs from which it was processed."[2] Thus, issues such as life-cycle versus waste-management reference points and the evaluation of upstream and downstream emissions boundaries make the calculation of solid waste's CDE footprint a considerable challenge.

The creators of this report have examined the possibilities of various emissions parameters associated with Middlebury's landfill, recycling, and composting solid waste stream, and have made several important determinations. In examining the process of recycling on campus, it has been determined that emissions associated with such activities as the collection trucks, machinery, electricity, and temperature control in the Recycling Center are all accounted for in the CDE footprints of the Transportation, Electricity, and Space Heating and Cooling sectors (Note: fuel usage from transportation of the recycled materials to Rutland County Solid Waste District *is* included in the totals for the campus fleet.) Similarly, in examining the composting process, it has been determined that emissions associated with the collection and transport of the material to the on-campus compost pile are already accounted for in the Transportation carbon footprint. The compost pile has a 'passive aeration windrow system' and thus does not use any energy to mechanically aerate the pile. As a result, while recycling and composting are important components of the solid waste stream, their CDE emissions are not included either in the emissions inventory or in this section of the report.

In contrast, the focal GHG-producing activity for Solid Waste is landfilling. After being sorted at the Recycling Center, waste destined for the landfill is brought to the Addison County Solid Waste Management District transfer station (Note: once again the fuel use from this transportation *is* included in the campus fleet.) From there, it is brought to the Waste Systems International landfill in Moretown, VT by the Addison County transfer station (Note: the fuel use from the transfer station to Moretown *is not* counted). Moretown is home to one of only two lined landfills currently operated in Vermont. The other is in the Northeast Kingdom (Coventry, VT), which is sixty-two miles further from the College than the Moretown Facility. Additionally, there is a $33.40 fee per ton to ship landfill waste to a facility out of state, thus eliminating the cost-effectiveness of that option. Once in Moretown, our landfilled waste contributes to the generation of methane emissions. Using a standardized methane-to-MTCDE conversion factor, over the past five years Middlebury has produced an average of 600 MTCDE per year. In relation to the entire college footprint, landfilled material produced by the college is responsible for 2% of Middlebury College's entire footprint per year.

V.2 Primary Stakeholders

On Campus: Students, Faculty, Staff as individual generators of solid waste; Facilities Management and the Recycling Center as waste management professionals; Dining Services as facilitators of composting.

Off Campus: Rutland County Solid Waste District (recyclables) ; Addison County Solid Waste Management District (landfilled waste); Waste Systems International-Moretown, VT Landfill (landfilled waste)

V.3 Summary of Objectives

1 Reduce Emissions Associated with Landfilling

Landfilling is the greatest CDE emitting activity associated with solid waste, and amounts to (on average) 40% of Middlebury's total waste stream. Reducing emissions associated with this activity is thus our primary objective.

2 Reduce Campus Material Consumption

As emphasized by the IPCC, "source reduction is indisputably the most environmentally sound and cost effective tool to reduce GHG emissions from solid waste." Our second objective is thus focused on the reduction of material consumption. Because almost 70% of Middlebury's recycled materials are paper products, and because paper manufacturing is surpassed only by chemical and petroleum refining industries in their industrial energy usage, our first three strategies focus on reductions in paper consumption. As emissions associated with paper manufacturing are upstream emissions not currently included in the emissions inventory, reductions in the use of paper could be counted as offsets. Our final strategy focuses on reducing overall material consumption, and seeks to hold groups within the College community accountable for their waste generation and provide incentives for consumption reductions.

V.3.1 Reduce Emissions Associated with Landfilling

Summary of Strategies

a. Support a Landfill Gas to Energy (LFGTE) co-generation project at the Moretown landfill—Scenario 1

b. Support a Landfill Gas to Energy (LFGTE) co-generation project at the Moretown landfill—Scenario 2

V.3.1.a – Support a LFGTE co-generation project at WSI Moretown landfill

Scenario 1-- Middlebury College makes capital investment and receives full carbon offsets from the project

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
43	None	12,500	$ (0.26)

Landfilling is the waste management practice with the greatest adverse affect on climate change: as matter decomposes in a landfill, a greenhouse gas mixture of approximately 50% methane (GWP of 23) and 50% carbon dioxide (GWP of 1) is produced. However, these gases can be captured and combusted in turbines to co-generate heat and electricity through Landfill Gas to Energy (LFGTE) projects. This strategy recommends that Middlebury College invests in a LFGTE project at our Moretown landfill.

In order for LFGTE projects to be viable, they need to fulfill certain criteria regarding the amount of waste in-place, the production of LFG (in cubic feet per minute), and the electrical generation needs of the surrounding community and utility. The maker of the Turbo Charger Gas Turbine (TCGT), Hervey Scudder of Brattleboro VT, has estimated that the Moretown landfill does indeed meet the requirements for their 100 kW microturbine. While Moretown currently captures their gases for flaring[3] to control undesired odors, they are also considering LFGTE co-generation. This strategy outlines the potential to reduce not only the emissions from Middlebury's share of the landfilled waste, but also the potential to reduce the emissions from the entire landfill. Consequently, this strategy of providing capital investment for a LFGTE project at Moretown creates a greenhouse gas offset mechanism.

A LFGTE project coming together in Moretown involves WSI (the landfill owner), Green Mountain Power, and the capital to purchase a LFGTE turbine (where Middlebury College enters the picture). Through contract negotiations, there are several possibilities for the College to receive both CDE credit as well as revenues from the LFGTE project. In this scenario, the College simply provides all of the capital investment, receives all of the carbon reduction credit, and receives none of the revenue.

Timeline

WSI and Green Mountain Power would have to enter negotiations about a LFGTE project. Middlebury College's pressure and capital could certainly speed up this process, but an agreement and implementation realistically will not happen until 2004 in the best case scenario. A working group exploring this issue among the three parties (MC, WSI, and GMP can begin this spring.

It should be mentioned that even after a landfill is closed it emits methane at similar rates for 10-15 years following the closure of the landfill. WSI's Moretown facility, for example, is scheduled to be full in 3-8 years, implying that this project could be in place until at least 2020.

Magnitude of Potential GHG Reduction

The total magnitude of the offset relies on the size of the generation unit installed and the percentage of the landfill contained under one cap. Our estimates range between 7,000 and 18,000 MTCDE. This estimate is based on the CO_2 currently emitted at the landfill. The physical structure of the landfill will determine how much methane one co-generation unit can convert. For instance, if only one cap exists onsite a co-generation unit can be installed and expect to convert nearly 100% of the landfill gas. However, if the site is fragmented the percentage conversion will be lower. Because the site is still receiving daily shipments of landfill material, we do not necessarily expect the recovery rate to be a full 100%, which is why we include estimates at 100%, 80%, 60% and 40% methane conversion. Once the Moretown facility closes, Middlebury College, or an outside party, may then decide to install additional LFGTE units, increasing the potential MTCDE savings per year.

Figures for each level of methane recovery are included in Table V.1. below.

Benefits and Costs

Fixed Cost

The cost of an entire LFTGE has been estimated at $50,000 to $80,000(source?).

Variable Cost or Benefit

No operating costs are foreseen. Once Middlebury makes our capital investment our involvement is minimal. Our recommendation for this scenario is that Middlebury makes a sizable capital donation to cover the start up costs of an LFGTE project and in return receive 100% of the carbon credits once Green Mountain Power realizes them.

Table V.1. Magnitude and Cost of Scenario 1.

Flaring vs. Flaring with Co-Gen	POTENIAL CARBON SAVINGS (MTCDE) Per year	Cost per ton (low end)	Cost per ton (high end)
		$50,000	$100,000
100% co-generation	18,393	$2.72	$5.44
80% co-generation	14,714	$3.40	$6.80
60% co-generation	11,036	$4.53	$9.06
40% co-generation	7,357	$6.80	$13.59
	**Flaring vs. flaring and Co-generation	**Estimate with TCGT	**Estimate with TCGT

Other Costs and Benefits

Environmental. This project would help to minimize the overall adverse environmental impact of the Moretown landfill.

Social. This strategy could help conceptualize, demonstrate, and reinforce the notion of a closed-loop economy, in which waste streams are utilized in further processes.

Public Relations. A positive relationship with Green Mountain electric would certainly be in the College's favor. Additionally, this project promotes Middlebury as an innovative and conscientious institution.

Cross-cutting areas and synergies. This strategy would provide a local and renewable means of producing electricity. And while this energy isn't returned to the college, it certainly decreases the overall carbon footprint of the State of Vermont.

Possible Financing Mechanisms

A partner would be helpful to offset much of the cost. Perhaps UVM would be interested in co-sponsoring the project, especially since their landfill materials also most likely to go to WSI.

Stakeholders

On campus

Facilities Management

Off campus

WSI[4] and the operators of the Moretown landfill; Green Mountain Power-the most likely utility to work out this type of deal with the makers of the Turbo Charger Gas Turbine.

Examples from elsewhere

Other Colleges and Universities

The EPA's Landfill Methane Outreach Program has a vast database of LFGTE projects that are already operating and that are being proposed.[5] Included in this inventory are LFGTE projects currently in place in Brattleboro and Burlington, which are noted directly below.

Other Institutions

There are several operating LFGTE projects in Vermont:

1) At the Burlington landfill that was closed in the early 1985, an electricity project began in 1991. At Interval they run several caterpillars on site and sell electricity back into the grid for the City of Burlington. Contact information: ???
2) In Brattleboro's landfill a LFTGE unit has been in place since 1982. Additionally Hervey Scudder is testing his smaller Turbo Charger Gas Turbine beginning in April 2003. Contact information: 257-0272.
3) The biggest project in progress is the Coventry landfill in the NE Kingdom. Washington Electric is planning to receive 1/3 of their grid from Landfill Gas beginning in 2003. Both parties are more than willing to share information as well as the agreement that both companies signed. Additionally, this document includes estimates on potential MTCDE savings, as well as startup costs, and electricity predictions (both cost and quantity) returned to the grid. The players:

Joe Gay- Casella Solid Waste Management at Coventry Facility. 223-7221. Casella entered an agreement with Washington Electric in 2002 which seems the model for a co-generation unit.

Bill Powell '77- Washington Electric. 223-5245. In agreement with Casella at Coventry site for a LFGTE project to begin in 2003.

Outside Vermont: Energy City. Elk River, MN Began LFTGE project in 1998, please see the following websites for a report on the project.
http://www.elkriverenergycity.org/Frame%20-%20demos.htm
http://www.elkriverenergycity.org/

Getting Started

The Landfill Site: Tom Bodowski- WSI in Moretown. He is a very busy person, so it may be best to work with Green Mountain Power and propose a project to present to WSI.

The Utility:

Green Mountain Power—**"The Guys Who Could Get This Done"**
Mr. Stephen Terry
Executive Vice President Green Mountain Power
Email: terry@greenmountainpower.biz
163 Acorn Lane
Colchester VT 05446
(888) 835-4672 Fax: (802)655-8419

One Possible Manufacture:

Hervey Scudder- Working on TCGT and more than willing to sell this technology as a feasible operational unit.
Hervey Scudder
Northeast Center for Social Issue Studies
Mail to: windrush@together.net
Web: www.necsis.org
802-254-3645

Works on LFGTE issues:

Meg Victor. EPA. Coordinates a database with all LFGTE projects on the East Coast.
Meg Victor
U.S. EPA (6202J)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Phone: 202-564-9193
Fax: 202-565-2079
victor.meg@epa.gov

V.3.1.b – Support a Landfill Gas to Energy (LFGTE) co-generation project at the Moretown landfill –Scenario 2

Scenario 2—Middlebury College makes capital investment and receives 50% of carbon offsets from the project, as well as 50% of the revenues.

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
27	3.4	6,250	$ 2.50

The details of this project are the same as for the previous scenario. Middlebury College works with WSI in Moretown and Green Mountain Power to install a LFGTE project at the Moretown facility. In this Scenario, Scenario 2, the College provides all of the capital investment, receives half of the carbon reduction credit, and receives half of the revenue.

This strategy will only come to fruition if Middlebury insists on the need and positive consequences of such a strategy. Due to the potency of methane in the atmosphere (23 times that of carbon) this project has both immediate need and implication. We recommend that Middlebury use their capital investment to receive both carbon credit and revenue from the project once it is online and convert methane into energy for the grid. This scenario has the greater payback and makes the most sense from a budget and economic perspective.

Timeline

WSI and Green Mountain Power would have to enter negotiations about a LFGTE project. Middlebury College's pressure and capital could certainly speed up this process, but an agreement and implementation realistically will not happen until 2004 in the best case scenario. A working group exploring this issue among the three parties (MC, WSI, and GMP can begin this spring.

Magnitude of Potential GHG Reduction

Scenario 2 recommends that Middlebury negotiate for 50% of the potential CDE savings. See Table V.2. for details.

Table V.2. MTCDE saved via Scenario 2.

	MTCDE saved per year (Middlebury College receives 1/2 of carbon credits)
Low end estimate (40% methane captured)	3679
High end estimate (100% of methane captured)	9196

Most realistic scenario based on our estimations	5500

Benefits and Costs

Fixed Cost

The cost of an entire LFTGE has been estimate at $50,000 to $80,000. (Based on estimates from the TCGT project). Scenario 2 has a return of $2.00 to $5.15 per MTCDE dependent on Middlebury College sharing 50% of the revenues with Green Mountain Power.

Variable Cost or Benefit

None foreseen. Middlebury College makes a capital investment in an LFGTE project and negotiates to receive 50% of carbon offsets from the project as well as the 50% of the revenues realized by Green Mountain Power once the project is operational. These profits are estimated at $18,900 per year. This profit will diminish over time following the closure of the landfill, but considering that most landfills have LFGTE projects operational between 10-15 years after closure and WSI is not scheduled for closure until 2006-2012, profits close to this figure can be realized for at least 18 years and will be expected to diminish from that point (See Table V.3.).

Table V.3. Scenario 2 Revenues.

100kW Co-generation unit	
Estimated kWh achieved by unit (annually)	840,000
Total Profits by Green Mountain Power at cost of $0.045 per kW hour	$37,800
Annual profit of Middlebury College (if receiving 50% of GMP profit)	$18,900
return per MTCDE	
Low end estimate (3700 MTCDE)	$5.14
High end estimate (9200 MTCDE)	$2.06
Most realistic scenario (6000 tonnes)	**$3.15**

Other Costs and Benefits

Environmental. This project would help to minimize the adverse environmental impact of the Moretown landfill, as well as remove the harmful methane now entering the atmosphere. This point is especially import considering methane is 23 times more potent as a GHG than CO_2.

Social. This strategy could help conceptualize, demonstrate, and reinforce the notion of a closed-loop economy, in which waste streams are utilized in further processes.

Public Relations. A positive relationship with Green Mountain Power would certainly be in the College's favor. Additionally, this project promotes Middlebury as an innovative and conscientious institution.

Cross-cutting areas and synergies. This strategy would provide a local and renewable means of producing electricity. And while this energy isn't directly returned to the college, it certainly decreases the overall carbon footprint of the State of Vermont.

Possible Financing Mechanisms

Since Middlebury is achieving a return on their investment a financing mechanism may not be needed.

Stakeholders

On campus

Facilities Management

Off campus

WSI[4] and the operators of the Moretown landfill; Green Mountain Electric-the most likely utility to work out this type of deal with the makers of the Turbo Charger Gas Turbine.

Examples from elsewhere

Other Colleges and Universities

None available

Other Institutions

See V.3.1.a.

Getting Started

See V.3.1.a.

V.3.2 Reduce Campus Material Consumption

Summary of Strategies

a. Establish Printing Fees

b. Reduce the number of printed copies for The Campus newspaper

c. Calculate waste generation by site

d. Eliminate Superfluous Catalogs/Junk Mail in Campus Mail Center

V.3.2.a – Establish Printing Fees

Summary data (10% reduction)

Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
1	0.01	19	$ 24,199

Summary data (20% reduction)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
2	0.01	39	$ 10,728
Summary data (30% reduction)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
3	0.01	58	$ 6,263

Currently office paper accounts for 40% of all recyclables on campus. Reprographics and purchasing alone purchased over 14 million pieces of paper in 2000, amounting to 4000 sheets per year for every faculty, staff member, and student on campus. As an institution, Middlebury College allows all faculty, staff, students, and guests free printing (in any quantity) from all printers on campus. Furthermore, each office and department on campus purchases their own additional paper, so there is currently no way to track the amount of paper coming to and being used on this campus.

By charging a set rate of $0.5 for every page printed, the College could not only offset the purchase price of paper but could significantly reduce the excess printing associated with a free-of-cost system, increasing the life of the printer, reducing the toner used, and reducing dependency on hard copies of each and every document created.

LIS (formally ITS) has begun tracking printing tendencies around campus. *The Paper Tracker* can be found at http://140.233.7.63/pagecounts/index.html and is scheduled to be released to the College community during the Spring semester 2003. The paper tracker will be able to record the difference in usage once printing charges are enacted, which is crucial to determining the amount of MTCDE emissions averted. .

Please note that personal printers will have to be addressed, as well as how to suit the printing needs of guests on campus. This is particularly important for summer school, when printing numbers have been seen to skyrocket, mainly because the computer labs are serving as a meeting place/caretaker of many not involved in the day to day activity of the college. The potential savings of this strategy during summer school is, therefore, tremendous.

Timeline

LIS has planned to implement a new printing fee system in the summer of 2004, allowing sufficient time to research many nuances of the plan, including time to purchase and install any new software.

Magnitude of Potential GHG Reduction

The following figures are only based on the 14 million sheets of paper purchased by Purchasing and Reprographics in 2000. This figure does not include the individual purchasing done on campus by each department. Therefore the potential magnitude of both cost and carbon savings is significantly underestimated (we would hope--but only if every department committed to a reduction strategy.

A 10% reduction in paper purchased accounts for 19.4 MTCDE saved.
A 20% reduction in paper purchased accounts for 38.9 MTCDE saved.
A 30% reduction in paper purchased accounts for 58.3 MTCDE saved.

These figures may prove to be an overestimate, however, because enacting this policy may increase computer usage and, hence, electricity consumption.

Benefits and Costs

Fixed Cost

Estimated at $1,000- to $5,000 for anticipated software required and changes that need to be made. Contact Carol Peddie in LIS for further information.

Variable Cost or Benefit

As listed in the first row in Table V.4, the cost of paper 14,100,000 sheets of paper in 2000 was $183,000, based on a cost of $.013 per sheet. Consequently, if the college were to charge only $.01 per sheet, the net cost of paper purchasing would range from $38,070 to $29,610, depending on reduction of paper use (here, the range form 10% to 30% is presented).

However, if the college were to charge $.05 per sheet, the net revenues to the college would range from $469,530 to $365,190, again depending on reduction of paper use

[EDITOR’S NOTE: these calculations vastly overstate the likely benefits, since they assume that $0.05 will be charged to someone on the campus for ALL paper used at the College, while the actual strategy only envisions charging students – who undoubtedly account for a significant share of the 14,000,000 sheets, but by no means all of them! In the next draft, we will present more feasible data – which we still believe will have the order of magnitude of the MTCDE and benefits of at least one tenth of those reported here.]

Table V.4. CDE Reductions and Cost Savings with Printing Fees.

	Total Sheets	Purchasing (cost) at $.013 per sheet	Net (cost) with a $.01 charge per sheet	Net benefit with a $.05 charge per sheet	MTCDE	MTCDE Saved	(Cost) per MTCDE saved (with $.01 charge)	Benefit per MTCED saved (with $.05 charge)
Current 2000 Level	14,100,000	$ (1,833,000)	$(42,300)	$ 521,700	194.4	0.0	--	--

Reduction Amount:								
10%	12,690,000	$ (1,649,700)	$(38,070)	$ 469,530	175.0	19.4	$ (1,958)	$24,149
20%	11,280,000	$ (1,466,400)	$(33,840)	$ 417,360	155.5	38.9	$ (870)	$10,729
30%	9,870,000	$ (1,283,100)	$(29,610)	$ 365,190	136.1	58.3	$ (508)	$6,264

Other Costs and Benefits

Environmental. Decreasing paper purchased by 20% is the equivalent of 12-22 trees per year. Decreased consumption is also a goal that the college should be striving for. Not only for the Environmental benefits, but also for the cost saving that using less entails.

Social. Potentially negative, Middlebury students hate to have policies imposed on them. Additionally, grumbling, especially from Faculty, Students, and Parents can be expected..

Public Relations. Makes Middlebury look Green on the Environmental front, helps achieve a zero-waste campus.

Cross-cutting areas and synergies. The electricity sector may be affected as this policy may involve greater computer use and hours spent online and using a computer.

Possible Financing Mechanisms

This strategy funds itself through the per-page printing fee.

Stakeholders

On campus

Students, Faculty, Staff. Recycling, Budget office, Purchasing, LIS

Off campus

Boise Paper, any alternative paper company we decide to invest in (i.e. any similar cost, more local provider of part post-consumer office paper product that was found).

Examples from elsewhere

Other Colleges and Universities

Amherst College: Charges students $.05 for each sheet printed on public printers.
Contact: Maura Fennelly mkfennelly@amherst.edu
Harvard College also charges the same.

Other Institutions

None found.

Getting Started

Contact: Carol Peddie (cpeddie@middlebury.edu) - Library Information Systems is currently researching this process and is planning for implementation for fiscal year 2004. She is looking for student volunteers to aid her in this process.

Also, companies exist that sell 'cool paper'-a CDE-free paper. Sue Hall at the Climate Neutral Network is the contact person. Please see section V.4.5 'Future Considerations".

V.3.2.b – Reduce the number of printed copies of The Campus newspaper

Summary data (3000 copies)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
24	Immediate	18	$ 174

Summary data (2000 copies)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
22	Immediate	54	$ 174

Summary data (1000 copies)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
21	Immediate	91	$ 172

Summary data (500 copies)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
20	Immediate	108	$ 174

Summary data (0 copies)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
17	Immediate	125	$ 175

The Campus newspaper is a valued part of the Middlebury College community. However, the average 3,300 – 3,500 copies printed for each weekly issue generate 38 metric tons of waste (equal to 2.98% of the College's total waste stream) and $21,875 in associated printing costs per year. This strategy outlines the GHG reductions possible through the elimination of paper copies (or alternatively, the incremental GHG reductions as a result of diminished numbers of printed copies) of The Campus.

Timeline

Immediate implementation

Magnitude of Potential GHG Reduction

The potential for both greenhouse gas reductions and monetary savings is substantial, as Table V.5 illustrates. (Note that the emissions factors used include upstream emissions.)

Table V.5. CDE Emissions Reductions and Cost Savings with Fewer Issues of *The Campus.*

Copies per issue	M tons Waste per year	Cost/yr	Cost savings	MTCDE/yr	MTCDE saved per year
3500	38	$21,875	$0	125	0
3000	33	$18,750	$3,125	108	18
2500	27	$15,625	$6,250	91	36
2000	22	$12,500	$9,375	71	54
1500	16	$9,375	$12,500	54	71
1000	11	$6,250	$15,625	36	91
500	5	$3,125	$18,750	18	108
0	0	$0	$21,875	0	125

Benefits and Costs

Fixed Cost

An online version is already up and running, so there would be no startup costs for reducing or eliminating paper copies.

Variable Cost or Benefit

No direct additional would be incurred for this strategy. The cost savings are presented in the fourth column of Table V.5. For example, if 500 copies of *The Campus* were printed, the cost savings would be $18,750.

Other Costs and Benefits

Environmental. Reductions in the quantity of printed copies of The Campus can save tons of newspaper resources each year.

Social. There may be considerable resistance or backlash to the total elimination of printed copies of The Campus. A survey investigating these issues could help address these concerns and better target printing needs.

Public Relations. This effort could undoubtedly be promoted as a conscientious waste reduction effort to enhance Middlebury's 'environmental' image.

Cross-cutting areas and synergies. Electricity sector, expecting the campus to be read online means increased computer use.

Possible Financing Mechanisms

None necessary.

Stakeholders

On campus

The Campus; faculty, staff, and students; Recycling center; Finance committee

Off campus

Printer (in St. Albans VT!); the printer's suppliers; Subscribers to the paper; Advertisers in the paper.

Examples from elsewhere

Other Colleges and Universities

Colby College and Bowdoin College have online versions of their campus newspapers. At both of these colleges, papers are not distributed to individual students, but rather to stands around campus. This is a system similar to that at Middlebury.

Other Institutions

While virtually all major newspapers have online versions, many have been forced to limit access or content in order to maintain subscription revenues. The Campus is overwhelmingly funded by the College, and thus is not as subject to these pressures.

Getting Started

Talk with Gabe Ortiz, the Business Director for *The Campus*. x4479, gortiz@middlebury.edu

V.3.2.c –Calculate waste generation by site

Summary data (1% reduction)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
34	None	6	$ (436)

Summary data (5% reduction)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
39	None	30	$ (18)

Summary data (10% reduction)

Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
40	0.9	59	$ 34

Currently, there are no established incentives for collective efforts to reduce material consumption on the Middlebury campus. This strategy therefore seeks to create incentives for waste reduction and disincentives for waste generation by establishing a means to hold community members accountable for their waste generation. This strategy involves the purchasing of a portable, battery-powered scale for each of the two Recycling Center trucks. With these scales, Recycling Center workers can weigh and record the amount of material waste generated at each site. This strategy also entails the hiring of work-study positions for students to present this information to the College community in creative and galvanizing ways[6].

Timeline

Immediate purchasing of scales and hiring of student workers is possible. This strategy has the potential to become a permanent facet of the College community.

Magnitude of Potential GHG Reduction

The potential for reductions is considerable, and depends upon the enthusiasm and fervor of consumption reduction efforts. The third column of Table V.6 illustrates the annual emissions reductions possible through reductions in the percent of landfilled waste[7]. Emissions reduction figures are based upon current landfill practices and thus do not take into consideration possible emissions reductions from the implementation of LFGTE projects. (Note: Material consumption reduction would also affect the amount of material recycled and composted. However, we have only included numbers for landfilled waste.)

Table V.6. Potential CDE Reductions and Cost savings per year

% landfilled waste eliminated	Total landfill	MTCDE saved	Cost savings (at $97 per ton)	Net (cost) or benefit	(Cost) or benefit per MTCDE
				[cost savings - $2,894 in wages]	
0	527.0	0	$ -	$ (2,894.00)	--
1	521.7	5.9	$ 511.19	$ (2,382.81)	($403.50)
2	516.5	11.8	$ 1,022.38	$ (1,871.62)	($158.47)
3	511.2	17.7	$ 1,533.57	$ (1,360.43)	($76.79)
4	505.9	23.6	$ 2,044.76	$ (849.24)	($35.95)
5	500.7	29.5	$ 2,555.95	$ (338.05)	($11.45)
10	474.3	59.1	$ 5,111.90	$ 2,217.90	$37.56
15	448.0	88.6	$ 7,667.85	$ 4,773.85	$53.89
20	421.6	118.1	$ 10,223.80	$ 7,329.80	$62.06
25	395.3	147.6	$ 12,779.75	$ 9,885.75	$66.96

Benefits and Costs

Fixed Cost

An initial cost of $1,910 would be incurred for the two portable scales. We recommend the InterComp CW250 portable platform scale (15" X 15" 300 lbs capacity model), which can be purchased from Farnham's Scale Systems for a total of $955.00 each, including shipping.

Variable Cost or Benefit

The recycling center has estimated that an additional hour would be needed each day to weigh the bags on the routes. Assuming student workers would perform this task, a cost of $1,630.20 would be incurred for an entire year (52 weeks) of wages (at $6.27/hour). The work-study position to coordinate and promote consumption reduction efforts would entail an estimated five hours per week for the academic year (36 weeks). This position would result in $1,263.60 in wages (at $7.02/hour). In total, total operating costs would equal $2,894 per year.

Middlebury College pays a flat 'tipping fee' of $97.00 per ton to landfill. The fourth column of Table V.6 illustrates the cost savings associated with the respective percentage reductions on landfill. The fifth column presents the net cost or benefit of this strategy. If the college reduces landfill by 5 percent, this strategy will have a net annual cost ($338.05); if the reduction is 10% or more, it yields a net annual benefit (from $2217.90).

Other Costs and Benefits

Environmental. Reduced waste generation will mean less land needs to be degraded for conversion to landfills.

Social. Reduced waste generation efforts can also create community awareness and a sense of conscientious stewardship.

Public Relations. A campaign that effectively addresses the issue of consumption can be used to enhance Middlebury's public commitment to the environment and further cement it's position as a leader in sustainable living.

Cross-cutting areas and synergies. Efforts to reduce material consumption could be vigorously coupled with efforts to reduce electrical and heating/cooling consumption.

Possible Financing Mechanisms

The budgets for Facilities Management have allotted student work hours that could be employed in these efforts. The Environmental Studies program could also employ students and aid in the coordination of consumption reduction efforts.

Stakeholders

On campus

Facilities Management, and specifically the folks at the recycling center; College accounting folks; Dining and the folks that operate the compost pile; all students, faculty and staff

Off campus

Waste Systems International (Moretown, VT), where our landfilled trash currently goes; Rutland County Solid Waste District, where our recyclable material goes

Examples from elsewhere

Other Colleges and Universities

At *Connecticut College*, the Environmental Model Committee works to reduce paper consumption and improve recycling rates[8].

The *University of Wisconsin-Madison's* Solid Waste Alternatives Program (SWAP) combines efforts to buy materials with high post-consumer content, reduce waste generation, and redistribute unwanted but usable materials[9].

Other Institutions

Many businesses have successfully adopted waste reduction policies, including Hewlett Packard, Xerox, and Fetzer Vineyards[10].

Getting Started

Talk with Campus Sustainability Coordinator, Environmental Council, Facilities Management, and the recycling center about effective publicity, incentives, and monitoring techniques.

V.3.2.d – Eliminate Superfluous Catalogs/Junk Mail in Campus Mail Center

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
35	None	6	$ (436)

Companies that sell mailing lists, as well as catalogue retailers, have targeted Middlebury College as a market with great potential. As a result, hundreds of unsolicited and undesired catalogues and direct mailings are sent to the College each week. In an entire year, this generates between 21 and 38 metric tonnes of mixed paper waste. While a few students may desire these catalogues, the vast majority of students does not, and furthermore is not even aware that they are included on these mailing lists. As David LeRose from the Mail Center explained, in order to stop the catalogues from coming, a cumbersome and time-consuming bureaucratic process (involving the contacting of each company and the removal of each student from the list) needs to happen. The Mail Center staff simply does not have the resources or time to complete this process. Thus, this strategy outlines a way in which work-study student wages could be used to work with the Mail Center and mailing list companies to remove students from these lists and thus effectively reduce the campus mixed paper stream.

Timeline

Implementation: Can be done immediately
Permanence: Process needs to be repeated throughout each year.

Magnitude of Potential GHG Reduction

Between 75 and 134 MTCDE could be saved, depending on the fluctuating volume and weight of catalogues that are received.

Benefits and Costs

Fixed Cost

None.

Variable Cost or Benefit

Approximately 8 hours per week could be productively employed in contacting companies and going through the mailing lists (which are not only Middlebury College students, but rather include all of the residents of the town of Middlebury). For the academic year, an estimated cost of $1,964.16 in student wages would be incurred.

It is important to note that our analysis of this strategy does not take into account the amount of time saved by the Mail Center and Recycling Center staff in not having to collect and manage this waste stream. Also, as the recycled material commodities market fluctuates daily, it has been impossible to estimate the impact of taking these catalogues and junk mail out of the College's waste stream, thereby affecting the volume of money the College receives for recycling mixed paper.

Other Costs and Benefits

Environmental. Reductions in catalogues and junk mail will mean less forest resources devoted to unnecessary paper, helping to maintain ecosystems.

Social. This strategy can help to minimize a sense of commercialism in the lives of students. Those who would like to purchase from these companies can use the Internet.

Public Relations. This strategy could create a delicate situation, and be misconstrued as animosity towards particular companies. However, it could also be viewed as a conscientious action to benefit the environment and lives of students.

Cross-cutting areas and synergies. This strategy will aid in efforts to reduce material consumption on campus.

Possible Financing Mechanisms

The budgets for student employment of the Mail Center and Recycling Center could allot money for these wages. In addition, the Environmental Studies program may have funds for this type of student employment.

Stakeholders

On campus

The Mail Center, the Recycling Center.

Off campus

The various catalogue and mailing list companies (examples: J.Crew; L.L Bean; Victoria's Secret).

Examples from elsewhere

Other Colleges and Universities

None found.

Other Institutions

Environmental Defense has extensive resources regarding this issue[11].

Getting Started

Contact David LeRose in the Mail Center (802 443 5179).

V.4 Future Considerations

V.4.1 Offsets through Native Energy and Foster Brothers Dairy Farm for new methane digester.

Support an offset portfolio from NativeEnergy that involves Foster Brothers Dairy Farm and their innovative methane digesters. (This is an excellent way of supporting local dairy farmers as well as efforts to provide local energy sources and mitigate greenhouse gas emissions). This is something our group strongly suggests looking into immediately. The public relations benefits are tremendous, as well as the potential to help the local community at a relatively low cost while offsetting our carbon footprint.

Contact:

Vermont Natural Ag Products, Inc.
297 Lower Foote Street
Middlebury, Vermont 05753
moo@together.net
800 639 4511; 802 388 1137

V.4.2. Support additional LFGTE projects in Vermont.

This is an excellent way to close the materials economy loop by utilizing a waste stream to generate heat and electricity. Several landfills in Vermont have the potential for successful LFGTE projects[12].

Contact:

Hervey Scudder
Northeast Center for Social Issue Studies
Mail to: windrush@together.net
Web: www.necsis.org
802-254-3645

V.4.3. Ecological Wastewater Treatment.

Address wastewater treatment by considering ecological purification and The Living Machine from Ocean Arks International (www.oceanarks.org).

Contact (a Middlebury alum):

Ryan Case
Director of Outreach
Ocean Arks International
176 Battery St, Suite 1
Burlington, Vermont 05401
802-860-0011

V.4.4. Default all Printers and Copiers on Campus to Double Sided.

Printer duplexers are currently on order for most printers on campus. However, education must go along with this process. Additionally, copiers on campus cost $.10 per sheet no matter if they are single or double sided. All copiers should be defaulted at double-sided and the cost should be more expensive if one decides to use single-sided. Again, an education piece must be included in this transition.

Contact for Printers:

Carol Peddie—she has all the information concerning the printer side.
LIS
peddie@middlebury.edu

Contact for Copiers:

Middlebury leases their copiers. The maintenance company is in Burlington, VT.

V.4.5. Investigate Climate Neutral Purchasing - 'Cool Paper'-

Contact: Sue Hall

sue@climateneutral.com
Climate Neutral Network
610 Middlecrest Road
Lake Oswego, OR 97034
ph: (503) 697-2798, fax: (503) 697-8853
webpage: http://www.climateneutral.com/default.cfm

V.4.6. Composting In All Campus Dining.

There are still a few places on campus that aren't up to par on composting practices, including Rehearsals Café, Breadloaf, and the Snowbowl.

Contact:

Matt Biette
Mbiette@middlebury.edu
x5244

V.4.7. Introduce composting in dorms.

It's worth a try especially if student volunteers can bring the compost buckets to a dining hall every few days.

Contact:

Connie Bisson
cbisson@middlebury.edu

x5043

V.4.8. Zero-energy building and Demolition/Deconstruction

Other groups are interested in this project including solid waste, especially since so much of our solid waste footprint is due to construction materials, from both the construction and destruction of buildings on campus. However, the demolition of the old science center sets a wonderful precedent for all college building in the future. This practice should continue and become the default policy.

V.5 References and Notes

1. Edited by Bert Metz, Ogunlande Davidson, Rob Swart, and Jiahua Pan. Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the IPCC. (Pages 230-235) 2001 Cambridge: Cambridge University Press.

2. Lester Brown Eco-Economy: Building an Economy for the Earth. (Page 122) 2001 NewYork: W.W. Norton.

3. ‘Flaring’ is an industry term for combustion.

4. Washington Electric also provides power to WSI, however they are currently engaged in a large scale co-generation project with Coventry landfill and do not have three phases of power into WSI as Green Mountain electric currently has. (Any co-generation project ideally needs three phase lines into the site so that electricity can be returned to the grid).

5. http://www.epa.gov/lmop/seek/seek.htm. Please note that the Burlington project

6. First, it can be used to facilitate inter-dorm and inter-Commons competitions. Second, it can serve as a mechanism for awareness akin to that of the Toxics Release Inventory (TRI), which forces businesses to publish the amount and types of chemicals they are releasing into the environment. The TRI has been very effective in encouraging businesses to voluntarily reduce their chemical releases. (A feature of The Campus could be weekly or monthly waste reduction/generation updates).

7. We pay a flat ‘tipping fee’ of $97.00 per ton to landfill, but Norm Cushman of Facilities Management estimates that overhead costs bring the per ton price of landfilled waste to $150.00. In 2002, we paid $78,982 to landfill 527 metric tons of waste.

8. http://camel.conncoll.edu/ccrec/greennet/Environmental_Policy/environmental_policy.html

9. http://www.fpm.wisc.edu/campusecology/cerp/swap/contents.htm

10. http://www.zerowaste.org/#strategies

11. http://www.environmentaldefense.org/system/templates/page/subissue.cfm?subissue=11

12.

Landfill Name	Landfill City	Landfill State	Waste In-Place (tons)	Year Landfill Opened	Landfill Closure Year	Landfill Owner	Project Status	Project Start Date	Project Developer	Utilization Type (Direct-Use vs. Electricity)
Brattleboro	Brattleboro	VT	1,000,000	1965	1995	Vermont Energy Recovery	Operational	1/1/1982	Total Energy Technologies/VER	Electricity
Burlington LF	Burlington	VT	863,000	1949	1985	Biomass Energy Partners	Operational	1/1/1991	U.S. Energy Biogas Corp.	Electricity
Lamoille District Transfer Station / Eden	Morrisville	VT				Lamoille Regional SWMD	Unknown			Direct
Town of Bristol Landfill	Bristol	VT		1989	2020	Town of Bristol	Unknown			Direct
Town of Randolph Landfill	Randolph	VT	190,000	1993	1997	Town of Randolph	Unknown			Direct
Town of Salisbury Landfill	Salisbury	VT		1989	2009	Town of Salisbury	Unknown			Direct
Town of Shaftsbury Landfill	Shaftsbury	VT		1989	2044	Town of Shaftsbury	Unknown			Direct
Waste USA Inc Landfill & Transfer Station	Coventry	VT	82,000	1991		Waste USA Inc	Unknown			Direct
WSI	Moretown	VT	80,000	1993			Unknown			Direct

VI. Sequestration

VI.1 Greenhouse Gas Emitting Activities

Our campus is presently taking the first crucial steps toward carbon neutrality, a state in which carbon sources = carbon sinks. Reducing the CDE sources on and associated with the campus is of utmost importance. However, this institution will never reach a point where there are zero CDE emissions. Therefore, we must simultaneously increase the number of sinks to enhance our carbon sequestration capabilities. Sequestration is the capture and storage of carbon that would otherwise be emitted and remain in the atmosphere. This can be done through terrestrial means, such as increasing forested land and improving agricultural practices. However, it is important to note that any such terrestrial sequestration is only temporary because carbon dioxide is removed from the atmosphere and stored in the earth's terrestrial reservoir. Over several decades, the CO_2 sequestered by these terrestrial pools will be released back into the atmosphere when the trees or crops die. Alas, this does not counter the anthropogenic sources of CO_2, released mainly from the burning of fossil fuels (taken from a geological reservoir with a time constant of millions of years). Improving terrestrial sinks only stores CO_2 temporarily, while buying us time to achieve further reductions, switch to cleaner and non-fossil fuel technology, and/or find permanent sequestration strategies to counter the changes made by taking carbon from the geological cycle. Such strategies may include geological and oceanic sequestration, both of which are at least a decade away from becoming viable options. Yet, regardless of whether one is concerned with temporary or permanent storage of CO_2, it is obvious that without carbon sequestration of some sort, carbon neutrality is not possible.

VI.2 Primary Stakeholders

On campus, the primary stakeholders include Middlebury College students, faculty, and staff, particularly Steve Weber (College Forester), the Office of Environmental Affairs, the Commons offices, the Admissions Office, the Volunteer Service Office, and the budget committee. Off-campus, stakeholders include residents of local communities who enjoy the College's forest lands, farmers who lease from the College, residents or institutions to whom the College's carbon neutrality is an inspiration, local plant nurseries, companies that market carbon offsets, and companies that sustainably harvest the College's timber.

VI.3 Summary of Objectives

1 Off-Campus Sequestration

Regardless of the reduction strategies Middlebury College adopts to decrease our CDE emissions, the campus will still produce a significant amount of CO_2. In order to achieve carbon neutrality, the college must account for and offset all of its emissions. Perhaps one of the most cost-effective ways to do this would be to use companies outside of our institution to sequester CO_2 into terrestrial landscapes.

2 On-Campus Sequestration

Due to physical constraints, the majority of the carbon sequestered on behalf of Middlebury College must occur off campus. However, because the college owns a relatively large amount of forested and agricultural land, we can use some of this property to employ carbon sequestration practices. In addition to the environmental benefits, Middlebury College will be one of the first academic institutions in the nation that actively plants trees and alters agricultural practices to combat climate change.

VI.3.1 Off-Campus Sequestration

Summary of Strategies

a. Forest Sequestration Offsets

VI.3.1.a – Forest Sequestration Offsets

Summary data (Future Forests)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
51	None	36,000	$ (16)

Summary data (American Forests – wildfire)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
44	None	36,000	$ (1.50)

Summary data (American Forests – normal)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
47	None	36,000	$ (3.00)

Summary data (Pacific Forest)			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
47	None	36,000	$ (3.00)

There is currently a developing market for CO_2 sequestration by way of conserving/producing terrestrial sinks (forests). Many offset companies undertake large projects of forest preservation or reforestation and offer clients the opportunity to offset their emission by paying for these efforts. Because these companies have access to particular sites around the world that are primed for reforestation and preservation, as well as the invested capital in undertaking such projects, it may be more cost-effective to sequester through these outside companies than to undertake an initiative here at Middlebury College. Yet, it is important to keep in mind that although terrestrial forests do sequester CO_2, they do so temporarily.[1] Eventually, any CO_2 that is stored in these terrestrial pools will be returned to the atmosphere (after only several decades) when the trees die or are used for fuel. This does not confront the issue of global warming directly because anthropogenic CO_2 emissions are mainly caused by the burning of fossil fuels (which are taken from the geological earth cycle, which usually takes thousands to millions of years to cycle the CO_2).[2] This difference between taking CO_2 out of the geological cycle, and trying to place it into the terrestrial cycle signals that the purchasing of forest sequestration offsets is only a TEMPORARY solution. However, it does buy us time by sequestering CO_2 for anywhere from several decades to a century—concievably long enough to make the switch to cleaner and greener technology.

Timeline

Immediate. Investments can be made now.

Magnitude of Potential GHG Reduction

Up to full college emissions can be offset (36,000 MTCDE).

Benefits and Costs

Fixed Cost

Startup costs are company-specific:

- Future Forests (UK based): \$16/tonne; 36,000 MTCDE = ~\$576,000

This company deals with many different types of offset programs, including reforestation, renewable energies, etc. Therefore, monetary investments to this program will be used according to the company's ideas of where the money has the most potential to offset carbon emissions. In addition, this company is involved in providing public relations assistance, as well as any individualized marketing associated with particular projects/companies. A combination of these two factors may help explain the higher cost per tonne.[3]

- American Forests: \$1.50 - \$3.00/tonne; 36,000 MTCDE = \$54,000- \$108,000

This company helps restore environmental areas both in the U.S. and around the world. They offer planting projects in specific areas (that have been previously identified for reforestation by the company) in urban, rural, and wildfire areas.[4]

- Pacific Forests (conservation): \$3/tonne; 36,000 MTCDE = \$108,000

This company primarily buys the conservation rights to private property lands, and then maintains the forests (through monitoring and restoration) for the lifespan of 99 years. Therefore, regardless of who owns the land over that time period (this person may change), Pacific Forests will have the rights to the conservation of that land.[5]

Variable Cost or Benefit

No operating costs. Once an offset is purchased, the company takes care of all planting and maintenance. The companies outlined have already accounted for risk factors (tree mortality, climate change, etc.) and over-plant accordingly to fit the projected offset amount. Yet, it is important to note that the offset takes immediate credit for all of the CO_2 sequestration within the 50-100 year life span of a tree, and any future offsets would have to come as a result of additional forestry projects.

Other Costs and Benefits

Environmental. Benefits: Development of ecosystems and animal habitats.

Social. Benefits: Aesthetic beauty around communities; investment in foreign and underprivileged communities.

Public Relations. Benefits: Middlebury College could be seen as 'Carbon Neutral'. Cost: simply buying offsets could be seen as taking the easy road.

Cross-cutting areas and synergies. N/A

Possible Financing Mechanisms

Alumni Donations and matching donations would be helpful in financing. It seems feasible that there are alumni within our college community that would be interested in seeing Middlebury College become 'carbon neutral.' Also, a possible voluntary portion could be added to the tuition bill that would offset each student's carbon footprint (price to be determined). Additionally, we could invest some of the money saved by reduction of emissions in other areas into the offsets.

Stakeholders

On campus

Students, Faculty/Staff, Budget Committee, Environmental Affairs Office.

Off campus

Alumni, Offset Companies, Forest conservation/planting site communities

Examples from elsewhere

Other Colleges and Universities

Connecticut College has committed to an offset program where it has helped plant trees in the Klinki tree project in Costa Rica.[6] This will offset 4.8% of the college's total emissions.[7]

Other Institutions

In the spirit of a 'green commitment' the following companies have purchased forestry offsets:[8]

-Eddie Bauer: $5,000,000 invested - helped plant over 5,000,000 trees
-Avis Car Company: 40,000 trees planted
-Virgin Car Company Pledges to plant:
  3 trees for every Peugeot 206 sold
  4 trees for every Volkswagon Golf sold
  6 trees for every Jeep Grand Cherokee sold

-Many financial institutions such as Barclay's bank, Swiss Re, etc.

Getting Started

It seems that of these three companies outlined, American Forests would be able to provide the most cost-effective offset program. Also, they have been recognized as a credible environmental conservancy organization since 1875. Furthermore, they seem to be adding something to the environment rather than just maintaining or conserving already existing lands (as Pacific Forests does). This idea of 'additionality' is more in line with a legitimate effort to provide more 'sinks' on the earth's terrestrial landscapes.

To get in contact with these companies:

Future Forests: Future Forests Ltd
4 Great James Street
London WC1N 3DB Tel: +44(0) 870 241 1932
Contact: Sue Welland email: sue.welland@futureforests.com

American Forests: American Forests Street Address: 910 17th Street NW, Suite 600
PO BOX 2000 Washington, DC 20006
Washington, DC 20013
Tel: (202) 955-4500 Fax: (202) 955-4588
Contact: Greg Meyer email: gmeyer@amfor.org

Pacific Forests: Pacific Forest Trust
416 Aviation Blvd., Suite A
Santa Rosa, California 95403
Tel: (707) 578 - 9950 Fax: (707) 578-9943
Contact: Michelle Passero email: mpassero@pacificforest.org

VI.3.2 On Campus Sequestration

Summary of Strategies

a. Preservation of College Forests

b. On-Campus Reforestation

c. Agricultural Sequestration

VI.3.2.a – On-Campus Forest Preservation

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
13	Immediate	5,000	$ 4

Middlebury College currently owns 4,000 acres of forested lands in the Green Mountains. Of this total, roughly 1,800 acres are actively preserved. Of the other 2,200 acres, 50 acres are sustainably cut each year, leaving a total of 3950 acres preserved each year.[9] These preserved acres serve as a tremendous carbon sink, as well as providing other academic and recreational benefits to the college community. We recommend that the college continue with its policy of preservation on as many acres of college-owned forest as possible. This strategy considers the possibility of preserving – by not harvesting – 50 acres per year.

Timeline

Immediate. The college must only extend its current preservation policy.

Magnitude of Potential GHG Reduction

The 4,000 acres of forested land currently sequester carbon dioxide – up to 300,000-400,000[10] MTCDE over a 100 year period (at 75-100 tonnes CO_2/acre), or between 3,000 and 4,000 tonnes per year.[11] Continuing to preserve these forests will not result in a net increase of carbon sequestration

However, preserving 50 acres of land per year would increase the current sequestration capabilities of the college's forests. We use an estimate of 100 MTDCE per acre or forest (SOURCE?)

Benefits and Costs

Fixed Cost

None.

Variable Cost or Benefit

The college makes between $40 and $800 per acre of harvested timber (possibly more depending on what land and who buys it), usually towards the higher end when it is sustainably harvested.[12] Preserving these 50 acres of forested lands could be considered lost potential revenue (opportunity cost) of approximately 50*$400=$20,000 (using the representative price of $400 per acre):

Other Costs and Benefits

Environmental. Maintains ecosystem health; provides habitat for resident species.

Social. Maintains academic and recreational resources for college community and others.

Public Relations. Allows the college to claim up to 4,000 acres of preserved, partially old-growth forest property.

Cross-cutting areas and synergies. Potentially could be affected by space heating and cooling group's plans to switch a college burner to biomass, which may come from college forests.

Possible Financing Mechanisms

Though this plan does entail some operating costs, it is already in effect. Therefore, the operating costs exist in the College's current budget.

Stakeholders

On campus

Steve Weber (College Forester); Connie Bisson (Environmental Coordinator); students, faculty, and staff who recreate and teach in forested areas.

Off campus

Potential sustainable harvesters (Vermont Family Forests, Island Pond Woodworkers, etc); residents who recreate in forested areas.

Examples from elsewhere

Other Colleges and Universities

Swarthmore College maintains a 325-acre arboretum.[13]

Other Institutions

American Family Forests, a sequestration offset company, buys and preserves existing forests[14]; *The Nature Conservancy*, an environmental non-profit, buys and preserves wild areas.[15]

Getting Started

Work with Steve Weber (College Forester) to ensure the conservation policy will be maintained.

VI.3.2.b – On-Campus Reforestation

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
45	None	2,800	$ (27)

Of the 4,000 acres of forested land owned by Middlebury College, 50 acres per year are sustainably harvested to provide wood for the college and other consumers. Within these harvested areas, roughly half of the trees are left standing.[16] In order to maximize the college's forests' ability to sequester carbon, these harvested areas could be actively reforested using native species purchased at local nurseries. Students participating in freshmen orientation, volunteer projects, and Commons activities could undertake this project for a somewhat higher cost than paying for forest offsets. However, we believe the additional benefits—improving local forest land, creating bonding experiences for groups of volunteers, maintaining an active and positive presence in the local community, etc.—make this a highly valuable strategy.

Timeline

Could be implemented within 1 to 2 years.

Magnitude of Potential GHG Reduction

Substantial. An acre of reforested land, averaging 1,500 planted seedlings, sequesters approximately 75 to 150 tonnes CO_2 per acre over a 100 year time period.[17] Because our harvested land contains one-half of standard tree density, our seedling number would be cut in half and would sequester an additional 37.5 to 75 tonnes (on average, 56) MTCDE per acre over a 100 year time period. Therefore, planting 750 seedlings/acre over 50 acres could sequester an additional total of approximately 2800 MTCDE.

However, it is important to note that this assumes that all additional sequestration is a result of replanting harvested forests. In reality, these forests would probably regenerate without such additional planting (as they are harvested sustainably), though over a longer time period. It is beyond our information to calculate how much any planting would speed up the process of additional sequestration (which would have an effect on the true cost/tonne CO_2).

Fixed Cost

This program would not require any startup costs.

Variable Cost or Benefit

The price of buying seedlings can range from $0.50-7.00/tree. Were the college to plant 750 seedlings/acre at $2/seedling (reasonable price range), the annual variable cost to plant 50 acres would be about $75,000.

Critically, we assume that groups of volunteers (consisting of freshmen participating in orientation, groups of students working through the Volunteer Service Office, and groups of students working through the Commons offices) would plant the seedlings, thereby eliminating any student or staff wages to plant these seedlings.

Other Costs and Benefits

Environmental. Repairs disrupted forest ecosystems; provides additional habitat for species.

Social. More timber is available for sustainable harvesting to provide revenue; provides good bonding and environmental experience for volunteers.

Public Relations. More timber is available for sustainable harvesting to provide revenue; provides good bonding and environmental experience for volunteers.

Cross-cutting areas and synergies. Potentially could be affected by space heating and cooling group's plans to switch a college burner to biomass, which may come from college forests.

Possible Financing Mechanisms

Grants from outside institutions; alumni donations or matching donations; redirect funds saved from reductions in electricity and/or fuel consumption; funds from optional "offset your carbon footprint" portion of tuition bill.

Stakeholders

On campus

Steve Weber (College Forester); Connie Bisson (Sustainability Coordinator; Volunteer Service Office; Admissions Office/freshmen orientation coordinators; Commons offices and deans; college budget office; students participating in volunteer reforestation projects.

Off campus

Potential harvesting companies; local nurseries; residents near reforested areas.

Examples from elsewhere

Other Colleges and Universities

No examples found of other colleges reforesting their own land for carbon sequestration.

Other Institutions

Carbon offset companies like Future Forests and Native Air plant forests to offset carbon for paying clients.

Getting Started

* Contact Steve Weber for locations, available dates, etc.
* Contact VSO/Admissions/Commons for help in organizing volunteers.
* Contact Andi Lloyd/Steve Trombulak to identify appropriate native species.
* Contact local nurseries to purchase seedlings.

VI.3.2.c – Agricultural Sequestration

Summary data			
Index rank	*Payback time (years)*	*Annual tonnes CDE*	*Total (cost) or benefit per tonne*
43	None	789	$ (26)

Sequestration efforts at Middlebury College have the potential to extend beyond the forests of the surrounding area. In order to maximize sequestration efforts at Middlebury College, agricultural practices can be modified to increase the amount of carbon dioxide being sequestered by crops and by the soil in which these crops are being grown. Carbon dioxide can be sequestered in the plants that are being grown and this delays the release of carbon back into the atmosphere for a short time. However, agriculture offers a more effective and slightly longer term possibility in terms of soil sequestration. There is much organic matter in the first meter of soil that has the ability to store carbon dioxide. Presently the college leases about 1900 acres of farmland to local farmers for relatively inexpensive lease prices. Conventional farming practices such as planting a monoculture crop and tilling the soil repeatedly can decrease the amount of carbon that can be sequestered in a given acre of farmland.

Crop rotation has become more popular over the years as a way to increase the longevity of an area of land by replenishing the nitrogen and other nutrients in the soil, and reducing pesticide costs by breaking weed and insect cycles. For instance, if a farmer were to plant a rotation of corn and soybeans (switching every 4 years), the soil would not become nitrogen deficient because the soybeans would fix nitrogen back into the soil. With an increased amount of nutrients and decreases in soil erosion, more carbon can be sequestered and in the end there is an increase in the crop yield.[30]

Crop rotation indirectly increases soil sequestration potential through increased nitrogen in the soil and general soil quality. However, this difference is small compared to differences tilling practices can make in soil sequestration. By implementing no-till agricultural practices, Middlebury farmland could increase its carbon sequestration by 30%. Tilling decreases the organic content in the land as well as being water inefficient; because of this, the amount of carbon the soil can sequester drops to almost zero. The flipside to minimum or no-till practices is that more herbicides must be used because the weeds are not buried in the tilling process. However, this effect can be counteracted by a more frequent rotation of the crops.[31]

One must also remember that agricultural sequestration, like any other form of terrestrial carbon sequestration, is only a temporary fix for a long-term problem. Because the carbon sequestered in agricultural crops and land is soon released back into the atmosphere, it can only buy us a little time until the technology and will exists to implement greener fuels and technology.

Timeline

The time necessary to implement this strategy would depend on the length and expiration of the lease agreements, which have a definite time span. After this time it would take one growing season to sequester the carbon in the plants and 3-4 growing seasons to fix a significant amount of carbon in the soil. This would then last as long as farming was occurring. The carbon in the soil would become part of the terrestrial cycle as long as these farming practices were still followed. However, this is a temporary solution in terms of sequestering carbon because it is such a short time (3-5 years for the crops and about 30 years for the soil) until the carbon is released back into the environment. Theoretically, soil carbon could be stored for millennia before being released back into the environment but because of our disruption of the soils, this time span in exponentially shorter.[32]

Magnitude of Potential GHG Reduction

The magnitude of carbon dioxide sequestered in this strategy would be dependent on improvements in two areas: soils and crop sequestration (Tables VI.1 and VI.2). Used together, these can provide a large carbon sink in the immediate area for this institution.

Table VI.1. Crop Sequestration Estimates.

CO_2 Sequestered	Corn Monocrop	Corn rotation w/ legumes
Gross (tonne CO_2/year)	1427	1661
Farming emissions	872	872
Net (tonne CO_2/year)	555	789

*Calculations in Appendix A

Table VI.2. Reduced Tilling Soil Sequestration.

Reduction in Tilling	tonnes CO_2

	sequestered
100%	7365
80%	5892
60%	4419
40%	2946
20%	1473
10%	737

* See calculations in Appendix A

With rotation the amount sequestered will rise 30% when compared with no rotation mono crops. Table VI.2 indicates the tonnes of carbon dioxide sequestered in the first five years depending on the amount of tillage reduction. Total carbon sequestered for the first year would be about 10,785 tonnes CO_2. After the first year, this would decrease because the soil can only hold a given amount of carbon.

Benefits and Costs

Fixed Cost

The costs for this strategy will take the form of subsidies for the farmers, if needed, and also any money that will be lost if farmers do not renew their leases because of the new policies. This strategy could strain farmer-college relations as well as relations with the general public. The costs are difficult to predict because of changing grain prices and our lack of in-depth knowledge of farming practices (meaning what would be required to plant different crops). However, seed prices are generally higher for soybeans than for corn. The startup costs would include new equipment; assuming half the farmers needed a tractor or planter to implement no-till practices, the cost would be about $16,000.[33] If this were to farm 50 acres, then the cost would be $30,4000 for all new equipment. Without calculating in the money government subsidies would cost the institution, this would mean the cost per tonne would be $20 (Calculations in appendix A).

Variable Cost or Benefit

Once started, the operating cost for the farmers would be roughly equal to what it is now, if not a little lower because of reduced pesticide use. However, the cost each year would have to include the money the state pays farmers to plant one crop as opposed to another because the farmer may be losing that if they are planting according to college requests.

Other Costs and Benefits

Environmental. Environmental results would be better soil quality and local ecosystem, but a cost would be the possible increased herbicide use.

Social. Social costs could be strained relations with farmers and other locals because of these lease changes. However, this could be offset by education provided about climate-friendly farming practices and organic growing.

Public Relations. Costs could be strained relations with farmers and other locals because of these lease changes. However, this could be off set by education provided about climate-friendly farming practices and organic growing.

Possible Financing Mechanisms

The money for this could come from money saved from other carbon emission reductions and/or from alumni donations and matching plans. Working with University of Vermont, a land grant university, Middlebury could try to influence the state to alter subsidies to farmers so that the institutions would have lower costs in utilizing this carbon sink. Excess crop production could be sold to biofuel companies. Money for this could also come from government grants for sustainable agriculture because there is a movement in Vermont to get such practices to be the default.

Stakeholders

On campus

The stakeholders for this plan would be the farmers themselves and the budget committee. The students and faculty would be stakeholders, because they are invested in community relations and carbon neutrality.

Off campus

Seed companies and farming equipment/supplies companies would be involved in the switch. State agricultural organizations would be invested in this switch as well because of food prices.

Examples from elsewhere

Other Colleges and Universities

UVM may be doing something similar because they are a land grant organization.

Other Institutions

None.

Getting Started

The first numbers to crunch will be the cost to the college. This will be based on many factors including, but possibly not limited to, seed cost, equipment costs for new planting methods and techniques, differences in income due to crop yield, and education on new farming techniques. These costs would also have to factor in what the state or federal government pays farmers to plant one crop as opposed to another. Other numbers to find would be what farmers are planting presently, how long their rotations are, and when the lease agreements are over.

VI.4 Future Considerations

VI.4.1 – Geological / Ocean Sequestration

A favorable carbon sequestration option is the technology that takes massive amounts of CO_2 (thousands of tonnes) and stores it in long term and permanent areas, particularly if we are to continue burning fossil fuels as a global society. The methods of geological and oceanic sequestration are highly complex and currently expensive technologies that offer just that solution. However, these strategies are not expected to be technologically or economically feasible for at least another 10 years.[18]

Geological Sequestration:[19]

A process by which massive amounts of $C0_2$ are removed from large source-point emitters (such as power plants) and stored into natural reservoirs, including those that have already been used for oil or coal bed methane extraction. These geological formations of porous rock offer potentially safe holding areas for large quantities of CO_2 below impermeable layers of rock, which can then be sealed and may provide permanent storage (barring any leakages). This kind of sequestration is already being done by oil extracting companies, yet the CO_2 used as part of the enhanced oil recovery (EOR) is taken from natural reservoirs of CO_2, not anthropogenic sources.

Oceanic Sequestration:[20]

A process by which massive amounts of CO_2 are removed from large source-point emitters (such as power plants) and stored in the ocean by way of direct injection. The CO_2 that has been sequestered must be compressed into a liquid and is then injected into ocean depths of at least 1000 m. Over the span of hundreds of years, some of this CO_2 may leak back up into the atmosphere. However, the deeper it is injected, the less likely this is to occur. Furthermore, as some of the CO_2 around the edges of the liquid bubble dissolves, it causes acidification of the surrounding ocean water.

Regardless of whether the one chooses to store CO_2 in the ocean or in geological formations, the process of obtaining the CO_2 would be the same for both processes. Scrubbers must first be installed on CO_2-emitting smoke stacks (such as the one at Middlebury College, which produced about 18,000 tonnes in 2000). Then, by using several chemical solvents and scrubbers, the CO_2 can be captured separately from all other gases exiting the flue, at which point it could be possible to compress the CO_2, store it in tanker trucks, and bring it to the storage site.[21]

Unfortunately, most of this technology is still relatively unavailable and certainly very expensive. The Department of Energy (DOE) has invested much effort and funding in researching these two areas of sequestration, and speculates that by the year 2015 a market for geological and oceanic sequestration may exist, at prices of $5-10/tonne.[22]

Timeline

About 10-15 years until viable technologies and markets emerge.

Magnitude of Potential GHG Reduction

A maximum magnitude of about 18,000 tonnes/year could be sequestered (by 2000 statistics) by installing scrubbers and using solvents on our current CO_2 emitting smokestack.

Benefits and Costs

Fixed Cost

On-site scrubbers, other machinery and materials (difficult to estimate approximate costs).

Variable Cost or Benefit

Chemical solvents: \$30-50/tonne CO_2 (depending on how 'pure' our CO_2 emissions are). These prices are expected to come down in the future.[22]

Energy inputs: Requires up to 50% energy increase (as technologies develop, this amount of energy input should also decrease).[23]

Transportation: \$1-3/tonne/100 km.[24]

Storage: \$1-2/tonne storage.[25]

So, for an estimated price of about \$100/tonne CO_2 sequestered, we could sequester 18,000 tonnes of the College's CO_2 for the price of \$1,800,000. Please note that due to the lack of some technologies, this price may be much higher than our estimate. Again, this price is expected to drop to \$5-10/tonne CO_2 in the next 15 years, which would total an expenditure of \$90,000-180,000.

Other Costs and Benefits

Environmental. Geological: Benefits: Fills vacuous aquifers which need to be filled anyway. Costs: Potential transportation pipelines through ecologically fragile areas. Oceanic: Costs: Acidification of water; destruction of marine ecosystems.[26]

Social. Geological: Benefits: If processed with Coal Bed Methane, may offset the costs.[27] Costs: Potentially dangerous (high pressures); could leak; community/industrial planning concerns (NIMBY). Oceanic: Costs: Potentially dangerous (high pressures;, international waters conflicts (NIMBY).

Public Relations. Benefits: Middlebury College Sequesters most of its CO_2 into long-term/permanent storage and is seen as 'carbon neutral'. Costs: Middlebury College seen as contributing to the destruction of oceanic/geologically sensitive areas.

Cross-cutting areas and synergies. N/A

Possible Financing Mechanisms

Alumni donations, as well as investment from the school itself. Also, maybe Middlebury College could agree to be an experimental case for companies who might do this in the future.

Stakeholders

On campus

Facilities management (complicated chemicals to be dealt with); students, faculty, and staff.

Off campus

Storage companies (oil?); transportation and trucking companies; areas through which the CO_2 would be transported; on site communities; scrubber/solvent companies.

Examples from elsewhere

Other Colleges and Universities

None

Other Institutions

About 1 tonne CO_2/ year is being stored in a deep saline reservoir about 800 m beneath the bed of the North Sea as part of the Sleipner Vest gas production project, purely for reasons of climate protection.[28]

Geological sequestration is done routinely by oil companies as part of enhanced oil recovery (EOR), but the CO_2 that is used comes from natural reservoirs, not anthropogenic sources.[29]

(As this is a futuristic long term proposal, much experimentation and simulations must first be run. Hence, there are not very many real life example of this going on right now.)

Getting Started

Wait for about 10 years before really looking into this technology, but possible contacts for further information now are:

Simon Shackley--Lead Researcher at Tyndall Centre for Climate Change Research
email: simon.shackley@umist.ac.uk tel: +44 (0) 161-200-8781

and *Manvendra Dubey* – Geochemistry Group Leader of the Earth and Environmental Sciences Division of Los Alamos National Laboratory
email: dubey@lanl.gov

VI.5 References and Notes

Forest Offsets Notes:

1. WWF Press Release. http://www.bsrsi.msu.edu/trfic/news_info/news_archive/20000602WWFKyoto.htm
2. http://www.environmentalsciences.homestead.com/carboncycle.html.
3. http://www.futureforests.com/
4. http://www.americanforest.org/
5. http://www.pacificforest.org/
6. http://www.conncoll.edu/ccrec/greennet/ccbes/klinki.html
7. Byard, Rebecca and Glasser, Aviva. Taking Action: Colleges' and Universities' responses to Climate Change. A report by students at Oberlin College. Dec. 2002.
8. http://www.futureforests.com/

On-Campus Forest Preservation Notes:

9. Weber, Steve. 1/22/03. Email conversation.
10. 4,000 acres of *newly forested* land would sequester 300,000-400,000 tonnes CO_2 during 100 years. The figure for already existing forests will probably be lower, but it is beyond our abilities to calculate this figure.
11. Edinburgh Centre for Carbon Management. 2000. Technical Document 1: Estimation of Carbon Offset by Trees.
12. Weber, Steve. 1/26/03. Email conversation.
13. Swarthmore College website. Accessed 1/26/03. www.swarthmore.edu
14. American Family Forests website. Accessed 1/18/03. **www.american**forest.org
15. The Nature Conservancy website. Accessed 1/25/03. www.nature.org

On-Campus Reforestation Notes

16. Weber, Steve. 1/22/03. Email conversation.
17. Edinburgh Centre for Carbon Management. 2000. Technical Document 1: Estimation of Carbon Offset by Trees.

Geological / Oceanic Sequestration Notes:

18. http://www.netl.doe.gov/coalpower/sequestration/geologic.html
19. http://cdiac2.esd.ornl.gov/scienceman.html#carbon
20. Metz, B, Davidson, O, Swart, R, Pan, J. 2001. Climate Change 2001: Mitigation: Contribution of working group III to the third assessment report of the intergovernmental panel on climate change. Inter-governmental Panel on Climate Change. Cambridge Press, NewYork. p. 250
21. http://www.fe.doe.gov/budget/02/full/02_sequestration.pdf
22. Metz, 250.
23. ibid
24. ibid
25. ibid
26. http://sequestration.mit.edu/pdf/Caldeira_et_al_NETL.pdf
27. Metz, 250.
28. ibid
29. ibid

Agricultural Sequestration Notes:

30. West, Tristram. Net Carbon Sequestration in Agriculture: A National Assessment. Environmental Sciences Division Oak Ridge National Laboratory. U.S. Department of Energy
31. Al-Kaisi. 2001. Impact of Tillage and Crop Rotation on Soil Carbon Sequestration. Iowa State University Extension.
32. Metz, B, Davidson, O, Swart, R, Pan, J. 2001. Climate Change 2001: Mitigation: Contribution of working group III to the third assessment report of the intergovernmental panel on climate change. Inter-governmental Panel on Climate Change. Cambridge Press, NewYork.
33. John Deere web site: http://www.deere.com/en_US/deerecom/usa_canada.html

VI.6 Appendix A: Calculations for Soil Sequestration

Crop rotation:

Middlebury farmland – 1900 acres
Carbon sequestered:
Corn 50.6 $gC/m^2/yr$ corn rotated w/ legumes 58.9 $gC/m^2/yr$

These numbers come from: West, Tristram. "Net Carbon Sequestration in Agriculture: A national assessment" Environmental Sciences Division Oak Ridge National Laboratory. U.S. Department of Energy

1lb = 453.59g
4046.87m^2 = 1 acre

Total amount sequestered for rotated crop

(58.9 $gC/m^2/yr$)(4046.87 m^2)(1 lb/453.59 g) = 525.49 lb/acre/year

(525.49 lb/acre/year)(1900 acres)(1 ton/2204 lb) = 453 tC/year

(500 tC/year)(44/12) = **1661 tCO_2/year**

Total amount sequestered for monocrop

(50.6 $gC/m^2/yr$)(4046.87 m^2)(1 lb/453.59 g) = 451.44 lb/acre/year

(451.44 lb/acre/year)(1900 acres)(1 ton/2204 lb) = 389.2 tC/year

(430 tC/year)(44/12) = **1427 tCO_2/year**

Total Carbon emissions from farming:

Corn crop 309.67 kgC/ha/year

These numbers come from: West, Tristram. "Net Carbon Sequestration in Agriculture: A national assessment" Environmental Sciences Division Oak Ridge National Laboratory. U.S. Department of Energy

(309.67 kgC/ha/year)(1000g/kg)(1 ha/2.47 acre)(1 lb/453.5 g) = 276 lb C/year/acre

(276 lb C/year/acre)(1 ton/2204 lb)(1900 acre)(44/12) = 872 tCO_2/year

Crop rotation:

1661 tCO_2/year - 872 tCO_2/year = **789 tCO_2/year**
Monocrop:

1427 tCO_2/year - 872 tCO_2/year = **555 tCO_2/year**

Soil sequestration:

Minimum till .6 tCO_2/year no till 1.8 tCO_2year

These numbers are from: West, Tristram, Post, Wilfred. "Soil Organic Carbon Sequestration Rates by Tillage and Crop Rotation: A Global Analysis." Soil Science America I 66:1930-1946(2002)

(.6 tCO_2/year)(1900 acres) = 1140 tCO_2/year

(1.8 tCO_2/year)(1900 acres) = 3420 tCO_2/year

Cost per tonne:

John Deer: tractor or planter = \$1600   replacement time: 15-20 years

(\$1600)(1900 acres/50 acres)/2 = \$304000

(\$304000)/(3420 tCO_2 + (789 tCO_2)(15years) = \$20/ tCO_2

VII. Conclusion: achieving carbon neutrality at Middlebury College

VII.1 Introduction

As noted at the end of Section I, we developed a methodology for sorting the strategies by a weighted combination of their financial impact on the college, their other benefits, and their relative levels of uncertainty and risk. In this section, we present, as examples for the CRI, two sample carbon neutral portfolios: for Fiscal Years 2005 – 2009, and for Fiscal Years 2010 – 2020. We feel that presenting our strategies in these different ways allows a range of Middlebury College stakeholders to begin to make conclusions about how to cost-effectively reduce our GHG impact.

VII.2 The selection of a carbon neutral portfolio

With the development of this logical framework and the ranking of strategies, it is a relatively straightforward exercise to develop a cost-effective carbon neutral portfolio. The first step is to order all of the strategies in descending order. One then must eliminate mutually exclusive strategies (for example, within Strategy II.3.2.a, different levels of fossil fuel reduction from the College's advocacy of renewables in Vermont.) One then selects strategies in descending order until the accumulated CDE is equal to the annual target (say, 40,000 tons). One can then use the accumulated average annual benefit or cost to estimate the total benefit or cost of this portfolio. In practice, as detailed below, this entails first selecting a number of diverse cost-saving strategies with 'reduce' and 'replace' objectives, and then selecting a set of cost-effective strategies with 'offset objectives.'

VII.2.1 A carbon neutral portfolio for Fiscal Years 2005 - 2009

Table VII.1 presents a sample portfolio for FY 2005 - 09. These include all strategies examined in this report which, in our judgment, could conceivably be up and running by FY05. As seen in the fourth column, these strategies are ranked, as discussed above.

[As noted above in Section V.3.2.a, the calculations associated with 'the print charge with a 30% reduction' are vastly overstated.. For this table and the subsequent table in this draft, we have, we have used figures that represent only 10% of the annual MTCDE and financial benefits calculated in the text. In the next draft, we will present more feasible data – which we still believe will have the order of magnitude of the MTCDE and benefits reported here.]

Column 6 calculates the annual cumulative MTCDE for the successive strategies. If all of these strategies were adopted, the College would reduce, replace, reduce, or offset a total of 35,428 MTCDE. Column 6 calculates the annual cumulative total cost or benefit for the successive strategies (using the average total cost or benefit data in column 7). If all of these strategies were adopted, the College would incur a <u>net cost</u> of $43,805.

Note that this method of examining the strategies allows the CRI to examine the respective financial and environmental advantages of the adoption of a range of strategies. For example, if the last two transportation strategies were NOT adopted – a decision which pits the criteria of cost-effectiveness vs. other deeply held environmental criteria -- the College would then reduce, replace, reduce, or offset a total of 35,4048 MTCED while incurring a net benefit of $161,195.

Table VII.1: Annual Carbon Reduction Portfolio for FY05 – FY09

(1) *Sector*	(2) *Report heading*	(3) *Strategy name*	(5) *Index rank*	(4) *Annual tonnes CDE*	*Cumulative tonnes CDE*	(16) *Average total cost (-) or benefit (+)*	(17) *Cumulative total cost (-) or benefit (+)*
Solid Waste	V.3.2.a	Print charge - 30% reduction [ADJUSTED]	3*	6	6	$ 36,510	$ 36,510
Electricity	II.3.1.a	10% residential electricity conservation education	8	80	86	$ 99,903	136,413
Heating/Cooling	II.3.1.a	Thermostat setpoints	12	459	545	$ 32,000	168,413
Sequestration	VI.3.2a	Preservation of Local Forests	13	5,000	5,545	$ 20,000	188,413
Electricity	II.3.1.c	Computer use education	14	29	5,574	$ 36,750	225,163
Transportation	IV.3.4.b	Collaborate w/ ACTR (public shuttle)	19	150	5,724	$ (1,500)	223,663
Solid Waste	V.3.2.b	Online Campus 500	20	108	5,832	$ 18,750	242,413
Heating/Cooling	II.3.1.d	Heating education campaign	23	23	5,855	$ 1,200	243,613
Heating/Cooling	II.3.2.b	100 low-flow shower valves	26	50	5,905	$ 4,118	247,731
Electricity	II.3.1.d.	Vending Misers (30% reduction)	28	3	5,908	$ 2,949	250,680
Transportation	IV.3.1.d	Reduce campus fleet use	29	150	6,058	$ 7,800	258,480
Electricity	II.3.1.b	3000 CFL bulbs (rebate $3)	30	6	6,064	$ 6,621	265,101
Transportation	IV.3.3.b	Charter biofueled coach buses	31	36	6,100	$ (3,881)	261,220
Solid Waste	V.3,2,d	Catalog Cancel	35	105	6,204	$ (1,970)	259,250
Transportation	IV.3.4.a	Student shuttles	37	250	6,454	$ (14,900)	244,350
Transportation	IV.3.1.b	Rideboard incentives	38	100	6,554	$ (1,200)	243,150
Solid Waste	V.3,2,c	Calculate waste - 10% reduction	40	59	6,613	$ 2,027	245,177
Transportation	IV.3.3.a	Switch diesel fleet to biofuel	41	440	7,053	$ (41,982)	203,195
Sequestration	VI.3.1a	Partial Emissions Offset-American Forests, wildfire	44	28,000	35,053	$ (42,000)	161,195
Transportation	IV.3.1.c	Employee commuting incentives/fees	46	130	35,183	$ (77,000)	84,195
Transportation	IV.3.1.a	Limit student vehicles	49	250	35,433	$ (128,000)	(43,805)

VII.2.3 A carbon neutral portfolio for Fiscal Years 2010 - 2020

Table VII.1 presents a sample portfolio for FY 2010 - 20. These include all strategies examined in this report that, in our judgment, could conceivably be up and running by FY10.

The preliminary data presented here suggest that by planning ahead, the College can not only be carbon neutral – they can also incur significant annual savings through a comprehensive portfolio of reducing, replacing and offsetting.

Table VII.2: Annual Carbon Reduction Portfolio for FY10 – FY20

(1)	(2)	(3)	(4)	(5)			(6)	
Sector	***Report heading***	***Strategy name***	***Index rank***	***Annual tonnes CDE***	***Cumulative tonnes CDE***		***Average total cost (-) or benefit (+)***	***Cumulative total cost (-) or benefit (+)***
Solid Waste	V.3.2.a	Print charge - 30% reduction	3	6	6	$	36,510	$ 36,510
Electricity	II.4.2	Switch to GMP under deregulation	4	61	67	$	266,852	303,362
Electricity	II.3.2.a	Advocate renewables (15% fossil fuel reduction))	5	134	201	$	86,035	389,397
Electricity	II.3.1.a	10% residential electricity conservation education	8	80	281	$	99,903	489,300
Heating/Cooling	II.3.1.b	Half biomass	9	11,000	11,281	$	273,840	763,140
Heating/Cooling	II.3.1.a	Thermostat setpoints	12	459	11,740	$	32,000	795,140
Sequestration	VI.3.2a	Preservation of Local Forests	13	5,000	16,740	$	20,000	815,140
Electricity	II.3.1.c	Computer use education	14	29	16,769	$	36,750	851,890
Heating/Cooling	II.3.1.c	Passive solar design	15		16,769	$	-	851,890
Transportation	IV.3.2.b	Replace gas fleet w/ diesel vehicles	16	5	16,774	$	2,067	853,957
Heating/Cooling	II.3.1.e	Window replacement	18	220	16,994	$	5,493	859,450
Transportation	IV.3.4.b	Collaborate w/ ACTR (public shuttle)	19	150	17,144	$	(1,500)	857,950
Solid Waste	V.3.2.b	Online Campus 500	20	108	17,252	$	18,750	876,700
Heating/Cooling	II.3.1.d	Heating education campaign	23	23	17,275	$	1,200	877,900
Electricity	II.3.2.b	Solar panelling	25	1	17,276	$	(60)	877,840
Heating/Cooling	II.3.2.b	100 low-flow shower valves	26	50	17,326	$	4,118	881,958
Solid Waste	V.3.1.a	Moretown methane capture (1/2 revenue)	27	6,250	23,576	$	15,650	897,608
Electricity	II.3.1.d.	Vending Misers (30% reduction)	28	3	23,579	$	2,949	900,556
Transportation	IV.3.1.d	Reduce campus fleet use	29	150	23,729	$	7,800	908,356
Electricity	II.3.1.b	3000 CFL bulbs (rebate $3)	30	6	23,735	$	6,621	914,977
Transportation	IV.3.3.b	Charter biofueled coach buses	31	36	23,771	$	(3,881)	911,096
Heating/Cooling	II.3.2.a	Solar water heating	33	5	23,776	$	2,833	913,929
Solid Waste	V.3,2,d	Catalog Cancel	35	105	23,881	$	(1,970)	911,959
Transportation	IV.3.2.a	Replace Gators and golf carts w/ electric vehicles	36	71	23,952	$	(4,030)	907,929
Transportation	IV.3.4.a	Student shuttles	37	250	24,202	$	(14,900)	893,029
Transportation	IV.3.1.b	Rideboard incentives	38	100	24,302	$	(1,200)	891,829
Solid Waste	V.3,2,c	Calculate waste - 10% reduction	40	59	24,361	$	2,027	893,856
Transportation	IV.3.3.a	Switch diesel fleet to biofuel	41	440	24,801	$	(41,982)	851,875
Sequestration	VI.3.2c	Agricultural sequestration	43	789	25,590	$	(20,267)	831,608

Sequestration	VI.3.1a	Full Emissions Offset-American Forests, wildfire	44	36,000	61,590	$	(54,000)	777,608
Transportation	IV.3.1.c	Employee commuting incentives/fees	46	130	61,720	$	(77,000)	700,608
Transportation	IV.3.1.a	Limit student vehicles	49	250	61,970	$	(128,000)	572,608

VII.3 Cross-cutting issues

In selecting the strategies that will comprise a carbon neutral portfolio, it is important to recognize that changes in one sector will often have an impact in other sectors. For example, a landfill gas-to-energy project could potentially reduce the emissions coefficient associated with Middlebury College's solid waste generation, but if that electricity is also part of the CVPS grid from which the college draws its power, it also shifts the electric fuel mix toward renewables. Hence, the MTCDE benefits of this one strategy will have important implications for both the Solid Waste and Electricity sectors of the campus footprint. Similarly, because the college steam plant uses cogeneration of electricity to step down the steam pressure before distributing it to the rest of the campus, any changes in the fuel used or quantity of steam produced at the plant will also have an impact on the fuel mix associated with electricity consumption.

As a result, the total MTCDE reduction for a given portfolio will not necessarily reflect the sum of the MTCDE reductions estimated for individual strategies when they are calculated independently. These synergistic effects between strategies can either increase or decrease the MTCDE reduction realized relative to the sum of individual strategies. For example, a reduction in thermostat setpoints (Strategy II.3.1.a), estimated to generate a reduction of 459 MTCDE from reduced consumption of #6 fuel oil in the steam plant, will actually generate a smaller reduction in MTCDE if combined with the implementation of the "half biomass" strategy (Strategy II.3.1.b.) which is estimated to reduce 11000 MTCDE by partially replacing the #6 fuel oil heat source. The total reduction is more likely to be on the order of 11230 MTCDE rather than 11459 MTCDE, when the change in fuel source is accounted for. Conversely, the combination of strategies can lead to cases in which the total is actually greater than the sum of its component strategies. For example, the replacement of older windows with new highly-efficient windows (Strategy II.3.1.e) is estimated to generate a reduction of 220 MTCDE. However, if this strategy is combined with a renovation implementing passive solar design (Strategy II.3.1.c. – estimates will vary depending on the specific project), the benefits of each strategy will be amplified and the total reduction in MTCDE maximized. Taken even farther, if passive solar design is implemented by replacing inefficient windows with solar PV curtain wall, benefits will be maximized in both the Space Heating and Cooling and in the Electricity sectors.

In some cases, estimating the combined effect of multiple strategies is more complex. An example would be the combination of solar water heating with the replacement of inefficient clothes washers and driers. In this case, the cumulative effect on water heating is reduced relative to the sum of both strategies, but there is a benefit in the form of reduced electricity usage by Energy Star appliances. These inherent complexities in assembling and evaluating a carbon reduction portfolio emphasize the need for careful monitoring at every phase of implementation. In addition, many of the estimated costs and MTCDE reductions proposed in the preceding chapters are time-sensitive, and will require re-evaluation as they are considered for adoption as part of a portfolio. These additional demands of monitoring and assessment are likely to involve some institutional changes, as described below in Section VII.4, however, the closer scrutiny of campus infrastructure and efficiency afforded by these activities can not only maximize the positive synergy of strategies under consideration, but can likely raise additional cost-saving opportunities for the college.

One final complexity to be acknowledged is the legislative and regulatory environment within which the college will be implementing these changes. To achieve the maximum MTCDE and monetary benefit of a carbon reduction portfolio, it is crucial that the college continue to support policies that promote and reward efficient use of energy and fossil fuels. The importance of this can be demonstrated by the "half biomass" strategy described above. Should the college reduce its current consumption of #6 fuel oil by 50%, it is likely that the supplier will raise the unit cost of #6 fuel oil on future purchases, thereby decreasing the anticipated monetary savings from the change in fuel. In this scenario, state and federal policies that reward emissions reduction and energy efficiency could help to balance the lost savings.

VII.4 Institutional opportunities

Based on our discussions with members of the Middlebury College community, we feel that a number of long-term institutional steps will need to be addressed in order to finalize and maintain a sustainable carbon neutral portfolio.

- Organization chart

Many stakeholders on the campus will be affected by the implementation a carbon neutral portfolio. As the work of the Carbon Reduction Initiative continues, we encourage them to examine the college's organization chart in order to fully identify those stakeholders.

- Sustainable campus and carbon neutral (SCCN) coordinator

We feel that the job description of the SCCN should be rewritten in order to help maintain and implement the college's carbon neutral strategy.

- Carbon neutral sub-committee of the EC (or CC), co-chaired by the SCCN coordinator and a representative from the controller's office

We encourage the members of the Carbon Reduction Initiative to recommend a formal oversight committee that will oversee the college's implementation of its college's carbon neutral strategy

- A monthly and public monitoring system of CO_2 emissions

We strongly encourage the college to develop a user-friendly, web-interfaced monitoring system (using the data entered in to the Banner system) that shows that the estimated monthly CDE.