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ACKNOWLEDGMENTS

The Environmental Studies 50 class of the 2000 Spring term would like to acknowledge Professor Richard Howarth for his guidance and insight throughout this project. The class would also like to thank the following people for their generous help and cooperation: William A. Barr Jr., Staff Transportation Survey Respondents, Van J. Chesnut (Executive Director of Advance Transit), William Hochstin, William Barr, Rick Hoffman, Kevin Evans, Mary Poulson, Lauren Cummings, Jason Angell, Roger Morse, Seth Hitchings, Kenneth Mosholder, Nancy Mclain, Catherine Henault, Michael Ricci, Charles Clark, Drew Hinman, Elaine Frank, Jane Piotrowski, Jennifer Nelson, Roderick Maclay, Earl Jette, Joel Sanborn, Andrienne Stone, Diane Armento, Spencer Simonds and Jen Coleman.

We would like to thank Karl Thidemann. Not only was he incredibly helpful in providing information about Solectria vehicles, he related pertinent information about electric vehicles themselves, and thus contributed greatly to the alternative vehicle section. We would like to thank Mark Perry for his expertise which provided the depth a document of this nature so needs. We would also like to acknowledge Mike Clement who truly gave his time generously so that we would understand the issues at hand.

EXECUTIVE SUMMARY

As one of the largest developed nations in the world, the United States is a major energy consumer and producer of pollution. A significant amount of this energy is used in the transportation sector. With a population of 280 million people, 250 million licensed drivers and 265 million vehicles, there is an excess of 15 million vehicles in the U.S.¹ The American commuter force accounts for about one tenth of the world's oil consumption,² and at least 50% of U.S. air pollution is caused by motor vehicle emissions.³

The Spring 2000 Environmental Studies 50 class has researched the transportation situation at Dartmouth College in order to establish its role in this environmental problem. We have determined that Dartmouth has much room for improvement in reducing the energy used and pollution produced by transportation on and around campus, especially when compared to other colleges and universities.

It is our hope that the recommendations we provide will be used to change transportation policies and practices at the college. The two major areas for improvement are among commuters and within the college fleet. College policies can influence the former and directly change the latter.

CHAPTER 2: COLLEGE COMMUTING

- The majority of Dartmouth commuters travel in single-occupancy vehicles, with an average fuel economy of 20.1 miles per gallon per vehicle.
- 88.5% of Dartmouth employees live between 0.75 and 70 miles from campus and overall, the average number of miles driven per vehicle per week is 112.95 miles.

¹ Perrin, Noel, personal communication, lecture, Apr. 2000.

² Miller, G. Tyler, *Living in the Environment: Principles, Connections, and Solutions* (Belmont, CA: Wadsworth Publishing Company, 1998) 402.

³ *Ibid.* 322.

- We estimate that these vehicles use a total of 12,615 gallons of gasoline per week, releasing almost 30 tons of carbon into the atmosphere per week.
- Alternative modes of transportation are not widely available, convenient or well-advertised and therefore not highly used.
- We recommend that employees be given a monthly transportation allowance which may serve as a cash incentive if they choose to use one of the alternatives to driving alone.
- We suggest that walking, biking, public transportation, carpools and vanpools all be encouraged and more actively advertised in print, electronically, and in meetings.

CHAPTER 3: DARTMOUTH COLLEGE VEHICLE FLEET

- The college's 130-vehicle fleet is composed entirely of conventional, gasoline-run cars, trucks, and vans. The fleet used 108,172 gallons of gasoline in 1999, costing the college \$67,067 for fuel alone.
- All vehicles are purchased by individual departments. No central management system exists for fuel purchase, vehicle purchase and maintenance, or vehicle sharing. This decentralization results in inefficiency.
- Given the amount and subsequent impact of the energy use associated with transportation at the college, Dartmouth should also consider the promotion of alternative vehicles both for the college fleet and commuters.

CHAPTER 4: ALTERNATIVE VEHICLES

- In our review of the alternative vehicles, we found that a number of college vehicles may be replaced by currently available electric and hybrid electric vehicles. Hypothetical replacements are described in table 3.1.
- An increase in the availability and affordability of electric and hybrid electric vehicles is predicted by 2010. These improvements will open up opportunities for their use at the college.
- Dartmouth should consider building charging stations and purchasing pilot vehicles.
- We recommend that the college implement a policy which requires the consideration of alternative vehicles whenever new vehicles are purchased. As the use of such vehicles becomes

more feasible in years to come, Dartmouth may be able to completely phase out conventional, gasoline-run vehicles and play a leading role in the battle to reduce automobile emissions.

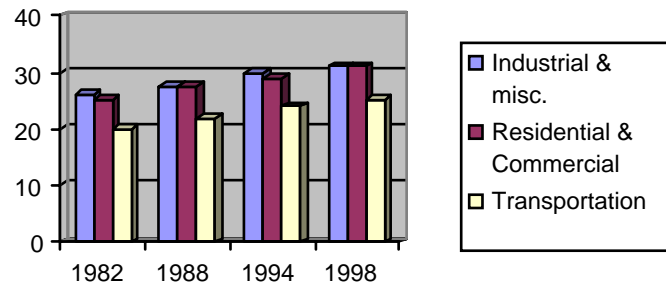
CHAPTER 1: INTRODUCTION

Energy is a crucial component necessary for the survival of the human race. However, it is possible that current practices for consuming this energy have caused social, economic, and environmental problems. As society advances its technology, we have to seek out and consume more sources of energy to fuel our needs. A source of energy which is unlimited and clean-burning would be one of the greatest treasures of today's society, but how far we may be from attaining such a source is uncertain. Nevertheless, it is clear in our current situation that energy use is accompanied by consequences. In fact, energy use is one of the biggest issues facing our society, since we must examine many aspects of the issue: from assessing the situation to implementing feasible policy recommendations. The task is indeed an enormous one, but progress is not impossible.

One area to which we can narrow our focus is the issue of transportation. This area is still crucial in global environmental energy issues, as demonstrated by such groups such as the Organization for Economic Co-operation & Development, who feel that "...the uncontrolled expansion of transport brings huge costs, both social and environmental..." a cost which they estimate to be between 4% and 6%.⁴ As shown by Figure 1.1, prepared by the United States Census Bureau, transportation is responsible for close to one third of energy consumption in the U. S. Combined with the huge role that automobiles play in our everyday lives, transportation is easily a critical component of the issue of energy use.

⁴ Organization for Economic Co-Operation & Development, *Climate Change & Environmentally Sustainable Transport*, Paris, France, 2000, May 2000, <<http://www.oecd.org/env/ccst/index.htm>>.

FIGURE 1.1 – ENERGY CONSUMPTION PATTERNS, BY SECTOR (QUADRILLION BTUs)



Since transportation is so important, the 2000 Spring Environmental Studies 50 class would like to use this report to examine the issue of energy use in transportation in greater detail, eventually narrowing the focus right to our doorstep - the Dartmouth community. We'll look at problems with transportation, the nature of our current situation, and possible responses, ultimately providing recommendations based on our findings.

In terms of general transportation issues, we want to provide a backdrop against which the rest of our study will take place, so we will look at two things: common problems (environmental and otherwise) associated with energy use in transportation, and the current statistical state of affairs of the United States in regards to transportation.

GENERAL TRANSPORTATION PROBLEMS

First and foremost, automobile emissions account for a vast array of problems regarding both the stability of ecosystems and human health. We can see in Table 1.1 that automobiles contribute to many of the airborne pollutants that are potentially hazardous to humans.⁵

⁵ Plepys, Christine, MS, and Fred Seitz, Ph.D., *Monitoring Air Quality in Healthy People 2000*, (Centers for Disease Control and Prevention/National Center for Health Statistics. Number 9, Sep. 1995).

TABLE 1.1 – SOURCES OF TRANSPORTATION-RELATED HEALTH RISKS

Pollutant	Health Risk
Tropospheric Ozone (O ₃)	Asthma, reduced respiratory function, eye irritation
Carbon Monoxide (CO)	Reduction in blood oxygen carrying capacity, impairment to cardiovascular and nervous system
Lead (Pb)	Retardation and brain damage (especially to children)
Nitrogen Dioxide (NO ₂)	Lung damage and respiratory illness

* Table 1.1 was obtained from the National Center for Health Statistics, in a report funded by the U.S. Department of Health and Human Services.

This information implies that many areas of the environment upon which we depend (such as the water we drink or the air we breathe) could be negatively impacted by transportation activity. In addition to the human effects induced by these criteria air pollutants, they also contribute to ecosystem effects. As you will see, in some instances these emissions are the direct cause of numerous environmental hazards, but in most cases they play the role of co-conspirator, contributing (along with other potentially hazardous processes) to an assortment of perilous conditions. In most places, emissions standards have generally reduced the amount of emitted pollutants during the recent past. However, it is still debated whether or not these federal regulations comply with a viable standard of living for the future. The following factors are relevant to our dissection of the transportation phenomena.

SMOG

Smog is one health hazard that automobiles potentially contribute to because of their direct emission of nitrogen oxides (NO_x), and the emission of volatile organic compounds (VOCs) from other sources. When these NO_x emissions combine with VOCs in a solar-heated mixture, they can form the pollutant ozone. While ozone is an essential component within the upper atmosphere, at ground levels it can be deadly for both humans and the environment in the

form of smog. It was found in 1998 that “personal vehicles (automobiles and light-duty trucks) alone produce 19 percent of NO_x and 22 percent of VOC emissions from all human sources.”⁶

According to a Morbidity and Mortality Weekly Report of the Centers for Disease Control and Prevention (CDC), the ozone portion of smog “reduces inspiratory capacity in humans” and it has been documented “that daily emergency department visits for asthma exacerbation are elevated following days of high ozone pollution.”⁷

In 1990, amendments to the Clean Air Act such as the National Emissions Standards Act (NESEA) were imposed, contributing to better regulation standards regarding ozone pollution. In addition, revisions to the National Ambient Air Quality Standard (NAAQS), dating back to the 1970 Clean Air Act amendments, reduced the amount of allowable ground-level ozone. Both policies are important steps in the attempt to ensure a viable ecosystem for the future.⁸

ACID RAIN

Not only do NO_x emissions contribute to smog, but they also play a role in the formation of acid rain. When the primary contributor, sulfur dioxide (SO₂), along with NO_x, combine with water vapor in the atmosphere, a poisonous cloud is formed leaving a trail of deadly precipitation behind it. Even though transportation does not contribute significantly to the emission of SO₂, the already emitted NO_x contributes to the creation of this dangerous combination.⁹ The U.S. Environmental Protection Agency (EPA) states that “According to recent studies at Harvard and New York Universities, higher levels of sulfate aerosols are associated with increased morbidity (sickness) and mortality from lung disorders, such as asthma and bronchitis.”¹⁰ Aside from affecting humans, acid rain contributes to the acidification of our waterways and to the accelerated decay of the structures that we have erected in the form of buildings, monuments, etc.¹¹

⁶ Environment Canada, *Exhaustion: A Guide to Transportation Emissions*, 12 Apr. 2000, <<http://www.ec.gc.ca/emission/toce.html>>.

⁷ (Centers for Disease Control and Prevention). *Morbidity and Mortality Weekly Report*, “Corporate Action to Reduce Air Pollution – Atlanta, Georgia, 1998-1999,” 3 Mar. 2000, 1 May 2000, <<http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/mm4908a2.htm>>.

⁸ United States Environmental Protection Agency, *Clean Air Act Amendments of 1990*, 1 May 2000, <http://www.epa.gov/unix0008/community_resources/water/muni/air.html>.

⁹ Environment Canada, 12 Apr. 2000.

¹⁰ United States Environmental Protection Agency, *Environmental Effects of Acid Rain*, 1 May 2000, <<http://www.epa.gov/docs/acidrain/effects/envben.html>>.

¹¹ *Ibid.* 1 May 2000.

The Acid Rain Program is another 1990 amendment to the Clean Air Act, and it is a step in the right direction, but acid rain is still very much a problem, particularly in heavily populated industrial areas.¹²

GLOBAL WARMING

Although the severity of the issue is highly disputed, another important factor to which automobiles might significantly contribute is global warming. “Emissions from motor vehicles account for 14 percent of global CO₂ production from the burning of fossil fuels” as of 1998.¹³ Carbon dioxide is considered to be one of the most potentially dangerous greenhouse gases (GHGs). Theoretically, these gases form a heat-trapping shield that creates a greenhouse-like effect and contributes to the warming of the earth. While this is a completely natural process, it is believed that carbon dioxide emissions as well as others are increasing the rate in which this process naturally occurs, and could have devastating consequences. Again, per capita, the U.S. are the highest global emitters of CO₂.¹⁴

The occurrence of such an event can have many consequences and has sparked environmental concern. The warming of the planet would obviously have a tremendous impact on our climate and weather patterns, which in turn would alter crop yields and raise sea levels. Generally, there is a deep concern for the possible impacts upon environmental and human health.¹⁵

“The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988, as a result of their concern that anthropogenic increases of emissions enhance the natural greenhouse effect and would result, on average, in an additional warming of the Earth's surface.”¹⁶ The result, four years later, was the United Nations Framework Convention on Climate Change (FCCC). While many of the most influential and substantially important countries such as the U.S., China, and India have ratified the FCCC, they have not signed the

¹² *Ibid.* 12 Apr. 2000.

¹³ Environment Canada, 12 Apr. 2000.

¹⁴ *Ibid.* 12 Apr. 2000.

¹⁵ United States Environmental Protection Agency, *Global Warming Impacts*, 1 May 2000, <<http://www.epa.gov/globalwarming/>>.

¹⁶ International Institute for Sustainable Development, *A Brief Introduction to the UN Framework Convention On Climate Change*, 14 May 2000, <<http://www.iisd.ca/linkages/climate/fcccintro.html>>.

Kyoto Protocol, an important byproduct of the Convention. Regardless, it has been an important step toward global action through a previously nonexistent communication network.¹⁷

OZONE DEPLETION

Another topic is the negative effect of the depletion of the stratospheric ozone. This effect is harmful to the planet, and it is known that widespread transportation has contributed to its depletion. We've already mentioned that tropospheric ozone itself can be extremely dangerous to human health at the ground level, but it plays an important role in the stratospheric ozone layer of the atmosphere, and in particular it shields off harmful ultraviolet rays that would otherwise wreak havoc on the ground. The primary contributors to this depletion are chlorofluorocarbons (CFCs). Unfortunately, "air-conditioning systems in motor vehicles are the third most important source of CFCs in the atmosphere" according to reports from 1998.¹⁸

According to the EPA, skin cancer (as well as several other skin defects such as premature aging), immune system suppression, and cataracts (to name one of several damaging effects to the eyes) are some of the essential risks related to ultraviolet exposure.¹⁹ With an increase in ultraviolet exposure to the earth, it is easy to see that critical environmental effects could also occur, particularly those related with altered vegetation yields and global warming, which we've previously mentioned.

Agreements such as the Montreal Protocol, and the Vienna Convention are again important steps in establishing a global communication network. Highly influential countries such as the U.S. have ratified both agreements while other superpowers such as China and India have elected to remain unsigned but in a favorable status of accession.²⁰

PARTICULATE MATTER

¹⁷ United Nations Framework Convention On Climate Change, UNFCCC, *Kyoto Protocol Status of Ratification*, 2000, 14 May 2000, <<http://www.unfccc.de/resource/kpstats.pdf>>.

¹⁸ Environment Canada, 12 Apr. 2000.

¹⁹ United States Environmental Protection Agency, *Health Effects of Overexposure to the Sun*, 1 May 2000, <<http://www.epa.gov/docs/ozone/uvindex/uvhealth.html>>.

Additional transportation hazards worth mentioning include emissions of carbon monoxide, benzene, polycyclic aromatic hydrocarbons, and aldehydes. Particulate matter is capable of carrying all of these substances. They are tiny airborne particles of dust or dirt that come into contact with the various toxic substances and serve as an adhesive and their means of transportation.²¹

Because of their size, they easily contribute to the irritation of lungs in human respiration. In addition to the irritation caused by breathing these dust particles, the toxic substances, if inhaled in large enough amounts, can then contribute to all of the health hazards above.²²

NATIONAL SECURITY

As the United States continues to escalate in population and the demand for energy continues to climb, it is becoming more of a necessity for us to go beyond the boundaries of our nation to acquire the energy that we need. For instance, current U.S. reserves are believed to be diminishing, at a rate substantial enough that we are now importing more petroleum than we are using from our own reserves. An issue of security then lies between the United States and the country or countries from which it is importing these resources. A major concern is that “political instability in any of the major producer regions could disrupt world supplies, leading to steep price increases,”²³ and we have seen this happen on more than one occasion in the last few decades. As one of the most influential and wealthy countries in the world, it is in our best interest to maintain the stability of our economy. One of the important tools used to maintain this economy is transportation, and in order to use this tool, we need petroleum to keep it functioning. At this point in time there is not a sufficient alternative, so transportation relies heavily upon our ability to obtain this resource. This makes “transportation particularly vulnerable should a disruption occur in the supply system.”²⁴

This issue of security creates an unstable foundation not only for our economy, but also for our environment. On one hand, we are happy to see low gas prices that contribute to the prosperity of our economy, but on the other hand, the signs of a good economy such as low gas

²⁰ United Nations Environment Programme, *The Ozone Secretariat*, 12 May 2000. 14 May 2000, <http://www.unep.org/ozone/ratif.htm>.

²¹ Environment Canada, 12 Apr. 2000.

²² Plepys, Christine, MS, and Fred Seitz, Ph.D.

²³ Bureau of Transportation Statistics, *Transportation Statistics Annual Report 1999*, “Transportation, Energy, and the Environment,” 12 Apr. 2000, <<http://www.bts.gov/programs/transtu/tsar/tsar99pf.html>>, 104.

prices "...encourage consumption, which generally means more imports,"²⁵ and unfortunately, pollution.

SUMMARY

Emission problems contribute to environmental degradation because of the dependence upon petroleum that co-exists with current transportation methods. Unfortunately, this dependence currently contributes to pollution through transportation. Our continued purpose throughout this report will be to suggest alternatives to this cause and effect relationship so that it might be avoided altogether. We've seen the effects that transportation has on human health and the environment, now we will look at some of the general statistics showing just how much transportation plays a role in each of our individual lives.

GENERAL STATISTICAL DATA

Much of the work in this report revolves around statistical data. For that reason, this section will go into more detail about some general statistical patterns of transportation in the U.S. Having provided some background about the problems surrounding transportation, this section likewise serves as a source for comparison when we discuss the status of our local area.

- *What are the average kinds of vehicles owned by American households?*

According to the U.S. Department of Transportation Federal Highway Administration's 1990 Nationwide Personal Transportation Survey (NPTS) Data book, 74.7% of vehicles were regular autos (i.e., cars), 4.9% were van/minibus, 0.6% counted as "other vans", 17.2% were listed as pickups, and 0.6% were "other trucks" (other vehicles of little use in this study were vehicles such as motorcycles and mobile homes, which account for the rest of the percentages). When these numbers are contrasted with the statistics from 1977, we find 79.6% auto, 2.0% van/minibus, 0.8% other van, 12.8% pickup, 1.3% other truck.²⁶ This information is important for comparing the types of vehicles found around Dartmouth with the rest of the nation. Already

²⁴ *Ibid.* 104.

²⁵ *Ibid.* 109.

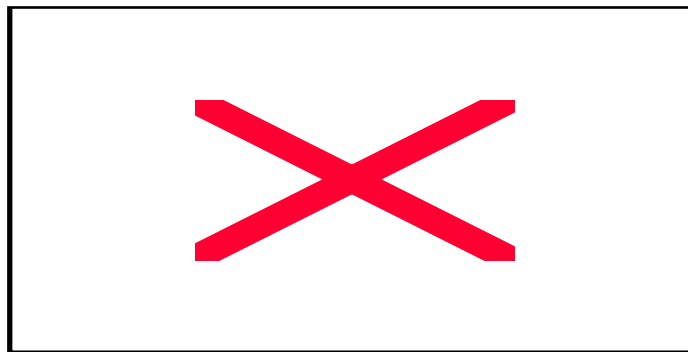
²⁶ Report on the 1990 NATIONWIDE PERSONAL TRANSPORTATION SURVEY (NPTS), prepared by Patricia Hu and Jenny Young, 1994, Apr. 2000, <<http://ntl.bts.gov/ntl/data/nptsall.pdf>>.

in the years represented by this report we see a shift away from autos towards less fuel-efficient vehicles such as minivans and trucks.

- *What are the average fuel economies of America's vehicles?*

The Transportation Statistics Annual Report 1999, prepared by the Bureau of Transportation Statistics, lists that average fuel economy since 1988 has remained in the range of 27.9 to 28.9 mpg. Note that this number reflects the “new passenger car fleet.” The report also points out that while “Automobiles and other vehicles are far more efficient today than at the start of the energy crisis of 1973... all the gain in new motor vehicle efficiency has been offset by increases in weight and power within classes, and by consumer shifts to lower economy vehicles.”²⁷ Figure 1.2, taken from this report, illustrates recent trends in vehicle consumption and efficiency.

FIGURE 1.2 – AVERAGE MILES PER GALLON, HIGHWAY VEHICLE CONSUMPTION²⁸



- *How much fuel does transportation consume each year?*

The data to answer this question is best summarized by Table 1.2, which can be obtained from the Statistical Abstract of the United States, 1999. Overall the increase of fuel consumption has been significant and consistent since 1970, particularly within the area of small trucks. Even if efficiency has been increased over the years, the previous data showing the consumers’

²⁷ Bureau of Transportation Statistics, *Transportation Statistics Annual Report 1999*, (U.S. Department of Transportation, Washington, DC 1999, BTS99-03), Apr. 2000, <<http://www.bts.gov/programs/transtu/tsar/tsar99pt.html>>, 105-106.

²⁸ *Ibid.* 106. Based on Figure 5.3, “Light Trucks” Includes vans, SUVs, and pickups. Information is for the entire fleet, not just new cars.

tendencies towards more inefficient vehicles combined with this data, does not demonstrate that the United States is a good example in terms of technical advancement and efficiency.

TABLE 1.2 – DOMESTIC FUEL CONSUMPTION PATTERNS (IN BIL. GAL.)²⁹

Year	All Vehicles	Cars	Trucks
1970	92.3	67.7	11.3
1980	115.0	70.0	20.0
1984	118.7	70.6	21.4
1988	130.1	73.3	22.9
1992	132.9	65.4	25.5
1996	146.7	68.9	29.5

• *How much do we spend on transportation?*

According to Chapter 3 of the Transportation Statistics Annual Report, American households spent an average of \$6,400 on transportation in 1996³⁰. Components of these expenditures primarily include the purchase of motor vehicles and parts, gasoline and oil, and transportation services. Of these components, vehicle purchases were the greatest.³¹

• *What about data for commuting?*

The Statistical Abstract tells us that nationwide approximately 84 million commuters drive to work alone (in a car, truck, or van), 15.4 million carpool to work, and 5.3 percent use public transportation. Average travel time to work is 22.4 minutes. For comparison's sake, the statistics for New Hampshire are 443 thousand driving alone, 70 thousand carpooling, and only 0.7 percent using public transportation. The average travel time to work in New Hampshire is 21.9 minutes.³² This seems relatively close to the national average, but perhaps it indicates that many people's perceptions in this area as particularly "green" are somewhat misinformed, as

²⁹ U.S. Census Bureau, *Statistical Abstract of the U.S. 1999* (Section 21), Apr. 2000, <<http://www.census.gov/prod/www/statistical-abstract-us.html>>, 651.

³⁰ TSAR 1999, Ch. 3, 68.

³¹ *Ibid.* 68-69.

³² Statistical Abstract, 641.

little thought seems to have been given to more efficient means of transportation than driving themselves.

- *What about regional differences?*

The Transportation Statistics Annual report sheds some light on this issue, claiming that “Historically, households in the West, on average, spent more on transportation than those in the Midwest, South, and Northeast.”³³ However, it notes that “In 1996, transportation’s share in total household expenditures in the South was 21%, 3% higher than in the West and Midwest, and 5% higher than in the Northeast,” an increase which the report claims results from new vehicle purchases. Nevertheless, the regions are within a few percent of each other.

SUMMARY

By now we have tried to establish the position of transportation as an important subset of issues under the larger umbrella of problems pertaining to energy use. We have looked at some of the general problems associated with transportation to explain why we think the issue is worth researching further, and we have provided some quantitative information to establish the national backdrop on top of which the issue of energy use in transportation at Dartmouth resides. At this point, then, it is appropriate to begin narrowing our focus down to the Dartmouth community.

³³ TSAR 1999, Ch. 3, 71.

CHAPTER 2: COMMUTING

In the age of technology, the car has come to represent much more than transportation: it is a symbol of status and affluence, of independence and freedom, of convenience and flexibility, of family life and even a symbol of gender. It provides convenience that can make alternative transportation seem obsolete – the bus is for a busy city, or for those who cannot afford a car; walking and biking are forms of exercise; carpooling creates inflexible and time-consuming schedules. National trends seem to reflect these sentiments. In the last twenty years, the United States has had a greater increase in cars than in people. Since 1970, the number of people driving has doubled, and the percentage of households without cars has decreased to twelve percent.³⁴ What many drivers may not often think about, however, is that these increases come at a higher cost than is shown on the vehicle's price tag or on the gas station pump. The average car goes 15,000 miles per year releasing 193 pounds of pollution.³⁵ Engine combustion, exhaust, and fuel evaporation have a number of health and environmental consequences. These emissions produce ground-level ozone, acid rain and smog, irritate eyes, damage lungs, cause respiratory problems, are linked to cancer, and contribute to the greenhouse effect.³⁶ Automobile emissions are linked to 30,000 deaths per year.³⁷ In cities across the United States, personal automobiles are the single largest source of pollutants.³⁸ For further discussion of the impacts of automobiles, see Chapter 1.

Twenty-eight percent of miles traveled in the United States each year come from the work commute,³⁹ in which the average automobile carries only 1.1 people.⁴⁰ Increases in

³⁴ Pisarski, Alan, *Commuting in America II: The Second National Report of Community Patterns and Trends*, 1996, (Eno Transportation Foundation Inc), 30 Apr. 2000, <<http://www.azfms.com/DocReviews/Feb97/art6.htm>>.

³⁵ *Vermont Rideshare Website*, 1996-1999, LocalNet Communications, LLD, 25 Apr. 2000, <<http://www.CommunityInfo.COM/rides/>>.

³⁶ *Automobile Emissions: An Overview, Fact Sheet OMS-5, 400-F-92-007*, Aug. 1994, (Environmental Protection Agency), 1 May 2000, <<http://www.epa.gov.otaq/05-autos.htm>>.

³⁷ *Bicycle Commuting: Subverting Our Car Culture: Air Pollution*, 1996, Language Learning at CALL, 15 May 2000, <<http://www.callcentre.bc.ca/lesson2/lesson2-3.htm>>.

³⁸ *Automobile Emission: An Overview, Fact Sheet OMS-5, 400-F-92-007*, Aug. 1994, Environmental Protection Agency, 1 May 2000, <<http://www.epa.gov.otaq/05-autos.htm>>.

³⁹ Pisarski, Alan.

⁴⁰ Marzotto, Toni, *et al.*, *The Evolution of Public Policy: Cars and the Environment*, (London: Lynne Rienner Publishers Inc., 2000).

commuting, fostered by housing patterns, time pressures and low costs, have served to offset the gains of cleaner cars and fuels.⁴¹ Until emission-free automobiles are more feasible, reductions in air pollution need to stem from changes in behavior. Commuter choice programs need to encourage the use of alternative transportation, reward those who are environmentally conscious, and build a sense of responsibility for the consequences of so many single occupancy automobiles. Leaving all other factors the same, if the national average of commuters per vehicle increased to 1.5 people per car (i.e. if more people carpoled), there would be 34 million fewer vehicle trips, leading to a decrease in emissions of 24 tons of volatile organic compounds, 34 tons of nitrogen oxides, and 216 tons of carbon monoxide each day.⁴²

A study conducted by the U.S Environmental Protection Agency of 5,000 employees in five major American companies concludes that reductions in driving are motivated most by schedule changes, and carpooling and other transit programs. A large determinant of willingness to alter current attitudes toward driving is environmental sensitivity.⁴³ Thus, programs addressing these motivational aspects and stressing the importance of “being green” are most likely to succeed.

Universities across the United States are taking the lead in altering attitudes toward alternative transportation. Programs stress the importance of environmental sensitivity and take an active role in promoting viable environmentally friendly solutions. Policies discourage single occupancy commuting through parking rates and incentive programs, develop innovative solutions to the obstacles that prevent a wider network of carpoolers, and encourage public transportation, walking, and biking. For a more detailed discussion of policies and programs at other schools, see the “Alternative Policies: Other Universities” sub-sections below. A review of Dartmouth’s current policies and transportation patterns, and the alternatives initiated at other universities sheds light on the path Dartmouth could take to a more sustainable future. We recommend that Dartmouth adopt policy measures to promote more environmentally-responsible behavior among faculty, staff and students, and that the school take greater responsibility for the impact of Dartmouth commuting on the environment.

⁴¹ Pisarski, Alan.

⁴² Marzotto, Toni, *et al.*

⁴³ *Ibid.*

EMPLOYEE COMMUTING AT DARTMOUTH

Energy Used, Gasoline Consumed, and Carbon Emitted on a Weekly Basis.

To begin our discussion of employee commuting at Dartmouth, we first attempted to assess the current commuting situation in the Upper Valley. In conversations with the Parking Operations Office, the Office of Residential Life, and through employee surveys we were able to gather information concerning Dartmouth's present parking and housing policies, and discern trends in employee commuting. In addition to researching current policy and surveying employees, we conducted an energy audit of commuting at Dartmouth. Through a series of equations, assumptions, and data gathering we were able to estimate the energy used, gasoline consumed, and carbon emitted during a week of commuting by Dartmouth faculty and staff. We left non-carbon pollutants (NO_x and SO_x, for example) out of this equation because technology for removing these pollutants varies significantly from vehicle to vehicle, and it is possible for these to be almost entirely removed with the correct technology. We were also unable to do a similar calculation for student commuting due to a lack of data on off-campus student distance from campus, and because the average distance would vary greatly term-by-term. We do not feel that leaving students out of the commuting equation is terribly problematic, though, since the number of commuting students is small in comparison to faculty and staff (2,875 employee parking passes are currently active vs. 429 student passes).⁴⁴

The following is a complete account of the methods we used in calculating the direct environmental impact of commuting at Dartmouth.

METHODS

To calculate the energy consumed (in BTU's), the gallons of gasoline burned, and the Carbon released (in pounds) each week by commuting Dartmouth faculty and staff we created the following equation:

⁴⁴ William Bar, Dartmouth College Facilities Operations and Management, Personal Interview, April 2000.

$$\frac{\text{Energy (BTUs)}}{\text{Week}} = \frac{\text{BTU}}{\text{Gallon (gasoline)}} \times \frac{\text{Gallons (gasoline)}}{\text{Mile}} \times \frac{\text{Miles}}{\text{Vehicle}} \times \frac{\text{Number of Vehicles Driven}}{\text{Week}}$$

$$\frac{\text{Carbon (lbs)}}{\text{Week}} = \frac{\text{BTU}}{\text{Week}} \times \frac{\text{Carbon (lbs)}}{\text{BTU}}$$

The following section describes how we found the value of each term (for quantitative results, see Tables below):

- Energy/gallon (BTU/gallon) was found on the EPA website.⁴⁵
- Miles/gallon (which we inverted to gallons/mile) was found using the Transportation Energy Data Book.⁴⁶ This source contains an estimate of on-road fuel efficiency (as opposed to the official test efficiencies, such as those used to comply with the CAFE standards, since test values tend to be significantly higher than on-road performance) for both light trucks (SUVs, Minivans, Pick-up Trucks) and passenger cars. To convert these two values (average efficiency of a light truck and of a passenger car) to the average fuel efficiency of a Dartmouth commuter vehicle, we conducted a parking lot survey. We visited the majority of Dartmouth faculty and staff parking lots on the main Dartmouth campus (excluding DHMC and college offices located outside of Hanover) categorizing over 1500 employee vehicles as either light truck or passenger car. This gave us percentages with which to weight the miles/gallon average.
- Average miles/vehicle/week was found in several steps. We first took a random sample of 200 addresses of faculty and staff members from the 1999-2000 Dartmouth Faculty and Staff directory. Using Mapquest,⁴⁷ we calculated the distance each lived from a central point, 31 N. Main St (Kiewit Computing Center), on the Dartmouth College campus. Figuring that the distance an employee lives from campus is likely to influence the number of trips s/he makes per week, we surveyed a different random sample of 200 employees. In this survey we asked, among other things, distance lived from campus and

⁴⁵ *Fuel Economy Impact Analysis of RFG*, 1995, (EPA Office of Mobile Sources), 15 May 2000, <<http://www.epa.gov/omswww/rfgecon.htm>>.

⁴⁶ *Statistics and Data Analysis*, 1998, Center for Transportation Analysis, 15 May 2000, <<http://www-cta.ornl.gov/Research/sda/T&S.html>>.

⁴⁷ <www.mapquest.com>.

number of trips made per week. Based on the 91 responses we received, we weighted our equation for number of miles per vehicle per week to reflect our finding that faculty and staff living very far away made fewer trips per week (see below for quantitative results). Also, from this survey we learned that mileage driven once on campus is negligible, narrowing our focus to commuting miles.

- The number of vehicles driven was found by using the survey to ascertain what percentage of faculty and staff drive (versus walk, bike, take public transport) to campus each day. We applied this percentage to the total number of faculty and staff working in Hanover (as listed in the staff directory) to arrive at an estimate of the number of vehicles driven. We did not use the total number of parking permits for the value of this term since we assumed that families with more than one car would have a permit for each even though only one car per household would probably be driven to Dartmouth on a given day.

RESULTS

TABLE 2.1: CONVERSION FACTORS

Energy/Gallon Gasoline	~113,500 Btu(varies seasonally)
Carbon/Unit Energy	41.8 lb / 1,000,000 Btu

TABLE 2.2: FUEL EFFICIENCY

Miles/Gallon (Passenger Cars on-road)	21.5 mpg
Miles/Gallon (Light Trucks on-road)	17.2 mpg
Percentage of Employee Vehicles that are Passenger Cars	67%
Percentage of Employee Vehicles that are Light Trucks	33%
Average Miles/Gallon of a Dartmouth Employee's Vehicle	20.1 mpg

TABLE 2.3: MILES/VEHICLE/WEEK

Distance Lived From Campus	Percentage of Employees living at this distance	Primary means of Transportation (to Dartmouth)	Percentage of <i>Driving</i> Employees	Average Miles driven per round trip	Trips made to campus per week	Average miles driven per week
< 0.75m	10%	Walk/Bike	0*	NA	NA	NA
0.75-70m	88.5%	Automobile	98.33%	19.64mi	5.67	111.35mi
> 70m	1.5%	Automobile	1.67%	207.2mi	1	207.2mi

Average Miles/Vehicle/Week: 112.95mi

*Because we are concerned with environmental impact due to gasoline consumption, the 10% of employees who primarily walk or bike are not considered in the average miles driven per week.

TABLE 2.4: NUMBER OF VEHICLES

Dartmouth Employees working in Hanover	2494
% Not Commuting by Automobile	10%
# of Vehicles Commuting to Campus	2245

CONCLUSIONS

Based on our calculations, we found that in weekly commuting Dartmouth faculty and staff consume an estimated 12,615.56 gallons of gasoline, resulting in the release of just under 30 tons of carbon into the atmosphere each week (1560 Tons/Year). Weekly commuting consumes approximately 1,431,866,026 BTU's (1.43×10^9 BTU's) of energy. If we included student commuting in these calculations, the numbers for energy used and carbon emitted would probably be about 1/6 higher. This is because there are about 1/5 as many student commuters as employee commuters & we would assume that they live closer to campus on average than employees. As we mentioned above, we were unable to calculate an exact number for student contributions because we could not obtain numbers for the average distance from Dartmouth that an off-campus student lives. To put the number in perspective, weekly employee commuting releases enough energy to power about 25,000 (100 watt) light bulbs continuously for a week. When these numbers are multiplied out to calculate yearly totals, employee commuting

consumes over 656,000 gallons of gasoline, uses 7.5×10^{10} BTU's of energy and contributes 1,560 tons of carbon to the atmosphere. In other words, Dartmouth faculty and staff commuting consumes well over a half million gallons of gasoline each year, enough to fill over 77 standard size tanker trucks⁴⁸. Using our light bulb analogy, the energy consumed during a year of commuting would be sufficient to fully illuminate 1,667 homes (15 bulbs each) continuously, day and night, for a year.

According to the 1995 Nationwide Personal Transportation Survey,⁴⁹ the national average daily commute to work is about 11.9 miles, slightly greater than the average Dartmouth employee's 9.8 mile commute. This reference also tells us that the percentage of employees relying primarily on autos, trucks, and vans for transportation at Dartmouth is similar to the national average, just over ninety percent. Dartmouth employees are also slightly under the national average for percentage of vehicles classified as light trucks (33% vs. a national average of 35%).⁵⁰ This national average is not limited to individual and family vehicles, however. Assuming that the inclusion of business-owned vehicles shifts the national average toward light trucks, there might actually be a higher instance of light truck ownership among Dartmouth employees than among American families on average.

The fact that Dartmouth is near the national average for commuting should not, we feel, be cause for complacency. Rather, as one of the nation's leading educational and research institutions, Dartmouth ought to be taking the lead in reducing the environmental impact of commuting. As we show in our "Policies and Recommendations" section, even amongst colleges and universities, Dartmouth is currently lagging in this area.

First, however, we will take a closer look at the factors driving these statistics.

DARTMOUTH COMMUTERS

A survey of Dartmouth staff and faculty reveals three primary means of transportation (See appendix 2.1 for full survey results). The majority, 90% of respondents, relies on private automobiles, while the remaining 10% live within a few miles of campus and bicycle or walk

⁴⁸ Sales Division, Pump and Tank Shop, Inc., Personal Communication, 8 May 2000, Calculation based on average volume of tanker trucks of 8500 gallons.

⁴⁹ Hu, P. and J. Young, *Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey*, (US Department of Transportation), 1995.

⁵⁰ Davis, Stacy, *Transportation Energy Data Book v. 19*. 1999, (Center For Transportation Analysis), <<http://www-cta.ornl.gov/data/tebdb19>>.

when weather permits. Of the 90% driving private automobiles, 7.3% report carpooling regularly (some with spouses) and 4.17% say they carpool on occasion. When asked, only 7.7% of respondents said they saw the automobile as the only means of transportation available and cited distance as the primary obstacle to alternative transportation, followed by a perceived lack of public transportation, the responsibility of children, and erratic work schedules.¹⁸ Of the approximately 2500 Dartmouth employees that work in Hanover, only 32% actually reside in town (anywhere within eight miles of campus). Roughly 40% of the Dartmouth staff and faculty reside outside of the closest surrounding towns, well beyond walking and biking distance, and, in many cases, beyond the scope of Advance Transit public bus service.¹⁹

TABLE 2.5: DISTRIBUTION OF DARTMOUTH EMPLOYEES BY TOWN²⁰

<u>Town</u>	<u>% of Dartmouth Employees</u>
Hanover	32%
Lebanon	9.30%
Norwich	9.20%
West Lebanon	5.18%
White River Junction	4.74%
Other	39.6%

¹⁸ Survey conducted by Julia Ford via Blitzmail to 200 randomly chosen Dartmouth Employees, to which 91 staff members responded, 17 Apr. 2000.

¹⁹ The Trustees of Dartmouth, 1999, *Dartmouth College Directory 1999-2000*. This book provided the basis for the number of employees living in each town and the total number of employees working out of the Hanover Campus.

²⁰ The Trustees of Dartmouth, 1999, *Dartmouth College Directory 1999-2000*. This book provided the basis for the number of employees living in each town and the total number of employees working out of the Hanover Campus.

TABLE 2.6: OBSTACLES TO THE USE OF ALTERNATIVE TRANSPORTATION²¹

<u>Top Ten Obstacles to the Use of Alternative Transportation</u>	
Survey Results from 94 Dartmouth Faculty and Staff respondents:	
2.	Live Too Far Away (24)
3.	No Public Transportation Available (17)
4.	Kids/Daycare (11)
	Demands of Job/Work Hours (11)
5.	Time (10)
6.	Weather (8)
7.	Schedule/limitations of the Current Public Transportation System (7)
	Inconvenient (7)
	None Available (7)
8.	Flexibility Offered by Automobiles (6)
9.	Unsafe Roads/Too Many Hills (5)
10.	Possibility of Emergencies (4)
	Cost (4)
	Errands to Run During Work Hours or on the Way to or from Work (4)
11.	Too Old for Walking and Biking (2)

POLICIES AND RECOMMENDATIONS

The following sections of this chapter address the current transportation system, examining Dartmouth and town policies, looking at transportation programs at other schools, and making specific recommendations for change. An overview of housing offers a backdrop to the discussion of commuting behavior as housing patterns determine the availability of alternative transportation, the energy expended, and the pollution emitted. The rest of the chapter examines parking, car/vanpooling, walking and biking, and public transportation issues. Policies at other schools offer insight into what Dartmouth could be doing to lessen its impact on the environment and public health. Recommendations for Dartmouth conclude each section and include promising solutions to single-occupancy vehicle commuting.

HOUSING PATTERNS AND DARTMOUTH COLLEGE

The population of New Hampshire has been increasing and is projected to continue to increase in the future.²² Dartmouth College, in particular, has seen higher and higher enrollment

²¹ Survey conducted by Julia Ford via Blitzmail to 200 randomly chosen Dartmouth Employees, to which 91 staff

figures which means not just more students, but more employees and further expansion of college and town services. As the population grows, zoning laws will have to adjust to a new urban character. In order to preserve the scenic quality of the Upper Valley as much as possible, town planners will have to direct policies toward discouraging the car-oriented suburban and rural sprawl that is becoming predominant all over the Upper Valley.

Dartmouth College is seeking to implement its future building projects in accordance with the principles of the New Urbanism model of neighborhood planning which discourages the sprawl fostered by current zoning laws. Such plans incorporate alternative modes of transportation (transit stops, bicycle paths, and pedestrian walkways), higher residential density neighborhoods, and streets designed to calm traffic with speed bumps, sharp corners, and narrow passages.²³

Development, housing, and town planning are intimately linked to transportation. Where the citizens of Hanover and Dartmouth students and employees live relative to downtown and the center of campus determines transportation patterns. The shorter the distance traveled, the less the pollution emitted, the less the fuel consumed, and the greater the efficiency. Dartmouth College assists some of its commuters with housing, either through employee housing programs or through off-campus housing for graduate and undergraduate students. Between 10 and 15 percent of Dartmouth commuters live in college-associated properties.²⁴ Housing policies could encourage or discourage more efficient commuting arrangements. The clustering of units would be helpful to car/vanpoolers, and housing projects with shorter commuting distances might encourage alternative modes of transportation, especially in conjunction with a lack of cheap, convenient parking on campus. Units could be located where easily accessible public transportation is available, or conversely, public transportation could be made available to housing developments.

members responded, 17 Apr. 2000.

²² *Hanover: 1996- 9218; 2000- 9574; 2005- 9799; 2010- 9892; 2015- 10049; 2020- 10303. Municipal Population Projections 2000 to 2020*, 1997, New Hampshire Office of State Planning (OSP), 7 May 2000, <<http://www.state.nh.us/osp/planning/SOC/MCDPROJ.htm>>.

²³ *Ibid.*

²⁴ College housing estimated at 427 units including: 397 rental units with another 30 housing units in Grasse Road development and 24 additional lots, multiplied by 1.2 to include housing with more than one affiliated occupant, divided by 3565 which includes 2500 staff/faculty plus graduate students: 300 Arts and Sciences Graduate Program, 450 Dartmouth Medical School, 135 Thayer School of Engineering, and 180 Amos Tuck School of Business Administration. $(427 * 1.2) / 3565 = .14 = 14\%$.

Dartmouth College Real Estate operates about 427 units of rental housing for employees and graduate students. Most of these are located within Hanover. About 140 units, just over 25%, are located within an estimated walking distance of 0.75 miles.²⁵ Other rental units are clustered in areas only 1.25-1.50 miles from the center of campus, making them reasonable candidates for carpooling and/or public transportation programs.

The college is currently planning new employee housing developments both to augment existing housing options and to make up for the expected housing displacement due to the expansion of undergraduate housing. These sites are the Grasse Road and Park Street developments. Grasse Road is a neighborhood of 30 single-family homes with 23 new lots for future home sites located approximately 2 miles east of campus. These houses are moderately priced options for administration and faculty.²⁶ The Park Street development will provide an additional 22 apartments for faculty and staff. This type of housing targets new hires, who are allowed up to seven years inhabitancy. Rent is raised after three years to discourage long-term occupancy.

Because there continues to be a considerable demand for college-provided and/or assisted housing, new housing projects are likely in the future. This may result in a higher proportion of the commuting pool living in such units, which would then have a larger impact on transportation because less people would be forced to drive. The Dartmouth Real Estate Office cites proximity to campus as its primary consideration for new housing.²⁷ As people want to reside closer to campus, Dartmouth Real Estate would like to build clustered units, creating neighborhoods of tight homes, but zoning laws continue to support rural and suburban sprawl as opposed to the New Urbanism envisioned by the college. This vision would have the effect of reducing dependence on cars and should be pursued, especially as long as on-campus parking continues to be scarce and/or inconvenient. Housing plans should be combined with policy efforts in other domains to encourage more environmentally friendly transportation practices, such as public transportation, carpooling, walking and biking.

Specifically, housing should be located within walking distance of campus whenever possible. When not feasible, housing should be clustered such that public transportation and

²⁵ Estimated from Plan #8 - Dartmouth College Employee Rental Housing, provided by the Dartmouth Real Estate Office.

²⁶ Grasse Road houses are \$175,000-\$250,000 as compared to the \$350,000 median price of a house in Hanover.

²⁷ Simonds, Spencer, Personal Interview, 25 Apr. 2000.

carpooling are convenient. Routes should be available between housing units and campus that are safe and convenient for bicyclists. Making more such college housing available to Dartmouth employees could save an average of 293 gallons of gasoline and 33,165,700 Btu of energy per year for each automobile commuter it enabled to choose alternative transport.

PARKING

CURRENT PARKING POLICIES

Dartmouth College currently offers parking to all faculty, staff and non-first year students for an average fee of about \$87/year (\$7.25/month, but there is not an option to pay by the month) for employees and \$11/term (3 months) for students. The College uses a sliding scale dependent on salary to determine parking fees for its employees. All fees, however, are significantly lower than at most other schools we researched (see Table 3.7). Parking cannot be paid for on a daily basis at Dartmouth, and there is thus no daily financial incentive except the price of gasoline for a person holding a parking permit to walk, bike or take public transport.

The total number of parking permits held currently by Dartmouth Faculty and Staff is 2,875 (there are a total of 2,494 Faculty and Staff listed in the Directory). Students hold 429 commuter parking passes. With 2,353 available spaces in Hanover, Bill Barr explained that there is no shortage of available parking at Dartmouth. What there is, however, is a lack of central parking that is convenient to buildings. In fact, when asked what parking-related complaints his office received most, Mr. Barr cited grievances related to this matter. When we compared this situation to that of other schools, we found that there are many (mostly larger schools) at which the parking is in general much more peripheral than it is at Dartmouth and commuters can take shuttles to different parts of campus. Dartmouth has recently made a move in that direction in the form of new bus services that travel every 10 minutes between two of the more distant lots and campus.²⁸

ALTERNATIVE PARKING POLICIES: OTHER UNIVERSITIES

Another way to discourage the use of single occupancy vehicles at Dartmouth College would be to increase parking fees. The rates at most other colleges are higher than the \$33.00 a

student commuter would pay for three terms, and significantly higher than the \$54-\$120/year paid by employees. At Emory University, there are seven different lots or zones in which students can park, and regardless of location, all students are required to pay \$291.00 per year for parking. Faculty and staff may pay anywhere between \$100.00 and \$900.00 per year for parking, depending on the location of the lot.²⁹ Cornell University charges resident students between \$270.87 to \$347.28 annually and commuting students \$270.87 to \$536.16.³⁰ Staff and Faculty have more options with regard to where they park and the cost. There is a free parking option that is located on the outer edge of campus (A-lot). There are five other tiers of parking that range in cost from \$250.81 to \$531.69 based on their proximity to the central campus.³¹ The university has a free shuttle that serves the Tier 2 parking and A-lot parking areas, running every 10 minutes starting at 4:25am and running until 2:30am seven days a week (begins later on weekends).³² The University of Michigan charges students \$87.00 or \$157.00 for parking permits in seven different locations. Faculty and staff pay between \$50 and \$872 annually for parking permits in four different zones.³³

TABLE 2.7: ANNUAL PARKING FEES

University	Student Rates	Faculty and Staff Rates
Dartmouth College	\$33	\$54 - \$120*
Cornell University	\$270-536	\$250 - \$532
Emory University	\$291	\$100 - \$900

²⁸ Barr, Bill, Assistant Director of Facilities Operations & Management, Personal Interview, Apr. 2000. All information on current parking and transportation policies collected in an interview and through email correspondence with Bill Barr, the Assistant Director of Facilities Operations & Management.

²⁹ Community Services and Parking Regulations, *Parking Regulations*, 1999, Emory University, 5 Apr. 2000. <<http://www.emory.edu/PARKING/regulations.htm#PartnershipforaSmogFreeGeorgia>>.

³⁰ Commuter and Parking Services, *Parking Permits and Rates: Undergraduate Students*, Cornell University, 16 Apr. 2000, <http://www.transportation-mail.cornell.edu/Commuter_and_Parking_Services/Level3/UndergradPermits.html>.

³¹ Commuter and Parking Services, *Faculty and Staff Parking Permits and Rates*, Cornell University, 16 Apr. 2000, <http://www.transportation-mail.cornell.edu/Commuter_and_Parking_Services/Level2/FacStaff.html>.

³² Commuter and Parking Services, *Faculty and Staff Parking Tier Structure*, Cornell University, 16 Apr. 2000, <http://www.transportation-mail.cornell.edu/Commuter_and_Parking_Services/Level3/FacStaffParkingTiers.html>.

³³ Mike Skora, *Student and Retiree Parking Options*, *Parking Services*, 1999, University of Michigan, 16 Apr. 2000, <http://www.plant.bf.umich.edu/parking/options/Students_and_Retirees.html>.

U. of Washington, Seattle	\$420	\$480
U. of Michigan, Ann Arbor	\$87 - \$157	\$50 - \$872

*Dartmouth rates are halved for part-time employees.³⁴

Stanford University, The University of Washington, and Cornell University have all adopted policies to limit the impact of their growth by not allowing an increase in the number of automobile trips generated by the campus. Stanford University has grown by 2 million square feet of new building space since 1991 (a 20 % increase), but its number of peak period auto trips to campus has remained the same.³⁵

The University of Colorado, Boulder has a policy that aims at creating a climate-friendly campus by reducing emissions to 7% below 1990 levels by the year 2010. The most current campus master plan (adopted February 2000) suggests walking and biking as the most preferable transportation methods. It addresses the university’s attempt to ensure affordable, proximate housing, and encourages cleaner transit for faculty and staff use.³⁶

“Blueprint for a Green Campus” an environmental action plan for the University of Colorado, Boulder, suggests that a better monitoring system is required to improve the campus environmental performance. For example, in order to be able to abide by the Kyoto Protocol, the school would require a baseline inventory on greenhouse gas emission on campus. In order to prevent an increase in traffic, there needs to be an agreed upon methodology for measuring traffic volumes generated by campus activities. The “Blueprint for a Green Campus” also recommends the need for a campus environmental council. Many policies are made on campus without any consideration of environmental impacts or alternatives. A good environmental council would serve the campus just as the EPA serves the United States.³⁷ Some universities that have approved a campus environmental policy and have established advisory or oversight committees:

³⁴ Bill Barr, the Assistant Director of Facilities Operations & Management.

³⁵ *Parking and Transportation Services: Incentives and Programs.*, 2000, Stanford University, 8 May 2000, <<http://bontemps.stanford.edu/transportation/proginfo.html>>.

³⁶ *The University of Colorado Master Plan*, 2000, University of Colorado, 22 Apr. 2000, <<http://www.colorado.edu/cuenvironmentalcenter/blueprint/page5.html>>.

³⁷ *Blueprint for a Green Campus: An Environmental Action Plan for the University of Colorado at Boulder*, 2000, University of Colorado, 22 Apr. 2000, <<http://www.colorado.edu/cuenvironmentalcenter/blueprint/index.html>>.

Many universities have established environmental committees and policies that provide guidance and funding to facilitate the reduction of car trips. Examples of these universities include Tufts University and the University of Oregon. "Tufts CLEAN!", an EPA funded program, aims at creating models for pollution prevention through the reduction of single-occupancy vehicles and the increase of carpooling and public transportation. The Tufts Environmental Literacy Institute (TELI), established in 1990, provides funding and tools to incorporate environmental issues into existing and new courses."³⁸

A part of the University of Oregon's Sustainable Development Guidelines is committed to sustainable transportation. The draft of the guidelines submitted in March 2000 states policies which discourage the use of single-occupancy cars and promote walking, biking, busing, and ride sharing.³⁹ Furthermore the plan is to link transportation planning to land-use planning. Knowledge sharing is also addressed as an integral part of such changes. The city of Eugene, where the school is located, also has a goal to accommodate transportation that promotes conservation of natural resources and is responsive to the community's needs. Construction of bike routes and the use of carpooling and buses are encouraged.⁴⁰ Furthermore, the school attempts to reduce transportation demand at peak time through shifting class schedules and locating some classes off-campus.⁴¹

The Alternate Transportation Program at UC-Irvine gives "courtesy dollars" and movie tickets when students participate in alternative modes of transportation, i.e., biking, walking, vanpooling, carpooling, or riding the school shuttle. The courtesy dollars are redeemable at the school bookstore, computer store, restaurants, bike shops, copy stores, and in the campus community.⁴² Such incentives are also offered at the University of Washington, Seattle through a program called U-Pass. The U-Pass funding comes from three sources: parking fees, U-Pass sales, and other university sources.

³⁸ Creighton, Sarah H. and Anthony D. Cortese, "Environmental Literacy and Action at Tufts University," *The Campus and Environmental Responsibility*, 20 (Spring 1992): 19-30.

³⁹ *University of Oregon Sustainable Development Guidelines*, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/>>.

⁴⁰ Childs, Jan, *Setting the Stage: the Role of Alternative Modes of Transportation in Local Planning Efforts: A Report by the Eugene Planning Director*, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/transpo/jchilds.html>>.

⁴¹ *Transportation System Analysis, University of Oregon, Executive Summary*, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/transpo/BRWreport.html>>.

⁴² *Transportation Systems Review Project*, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/transpo/BRWreport.html>>.

The University of Buffalo is a member of the Clean Communities of Western New York,⁴³ a local organization which promotes the use of alternative fuel vehicles. Furthermore, UB has a natural gas refueling station, which accommodates the 20 vehicles in the college-owned fleets that are powered by compressed natural gas.⁴⁴

RECOMMENDATIONS FOR DARTMOUTH: PARKING

We recommend a number of fundamental changes in campus parking policies that will discourage driving on campus, encourage other modes of transportation, and reward those who participate in alternative programs.

- *Increased Fees for Parking and Registration.* This would discourage students from bringing cars to campus and encourage the use of alternative transportation. For employees, this would also provide a financial incentive against driving, which could be backed up by a compensation program, described below, so as not to penalize those for whom alternative transport is simply not an option.
- *Compensation Program.* Dartmouth should implement a Transportation Allowance Program. The College would add a lump sum of money as an allowance to each employee's paycheck that would cover increased registration and parking fees. The employee would then either use that money to pay for parking, or receive it back as compensation for using more environmentally friendly transportation. Employees using public transportation, alternative fuel vehicles, biking, walking or carpooling would keep the initial allowance. Although this might seem like an extreme cost to the college, there are a number of financial benefits. First of all, the College would regain some of its expenditures through increased parking fees. If this policy succeeded in reducing the number of daily commuters, the College would save money on parking lot expenses, and would not have to build new parking lots. Although they may not seem so, parking spaces are extremely costly to provide, running upwards of several thousand dollars per

⁴³ NEWS: *Clean Communities of Western New York Teams up with Erie County for Earth Day 2000*, Clean Communities of Western New York, 15 May 2000, <<http://members.aol.com/Legis14/clean.htm>>.

⁴⁴ *Environmental Task Force Campus Projects*, University of Buffalo, 19 Apr. 2000, <http://wings.buffalo.edu/ubgreen/groups/ETF/ETF_projects.htm>.

space just in construction costs,⁴⁵ not to mention maintenance, such as winter plowing. Additionally Dartmouth would be able to convert some existing parking lots to other uses for which they are ideal, such as housing. In a time when building space is scarce and the College needs to expand its facilities, this type of payback would make an investment in a Transportation Allowance seem meager. Finally, Federal tax advantages are also available to employers who provide qualified transit, car/vanpool and parking programs. The college would be exempt from paying payroll taxes on these benefits, and could deduct the value of the benefits from income taxes.⁴⁶

- *The Pay-By-The-Day Option.* Dartmouth should, in addition to its annual parking rate, offer the option of paying by the day for those employees or visitors who do not (or might choose to not) park on campus enough to invest in a parking pass. These employees/visitors would purchase coupons or passes in advance and use them whenever they need to park on campus. This would be beneficial to those employees who would normally walk or bike but might need their cars occasionally or when the weather is unfavorable. Dartmouth could buy back any unused coupons at the end of the term, encouraging employees to drive as little as possible.

- *Priority Parking for Environmentally Friendly Transportation.* To encourage the use of alternative fuel vehicles, carpooling, and vanpooling, Dartmouth should offer those who use them free parking, and the best, or most convenient, parking spots on campus. Dartmouth already does this for 3+ member carpoolers, but the program is under-publicized and not backed up by emergency solutions (see Recommendations for Dartmouth: Car/vanpooling for details). We are very pleased to see that Dartmouth has taken this step toward increasing the convenience of carpooling, but to make it truly effective, the College must follow through on the details.

- *After-hours Parking Monitoring.* To decrease the amount of unnecessary on-campus student driving, the College could consistently monitor student parking after traditional working hours and concentrate their efforts on the problem areas, such as outside Kiewit and Thayer Dining Hall. The revenue from these violations could help fund the Cash Allowance Program and discourage student driving.

⁴⁵ Wilson, Jack , Dartmouth College Planner and Architect, Personal Interview, May 2000.

- *Publicity.* It is crucial that Dartmouth thoroughly publicize any new plans and programs. We recommend the establishment of a transportation blitz bulletin, distribution of literature at orientation sessions and like events, and other means of (frequently) getting the word out on the new programs and the environmental benefits that can be gleaned from them.

CARPOOLING/VANPOOLING

CURRENT CARPOOLING/VANPOOLING POLICIES

Dartmouth College Parking Operations has in place a program offering significant benefits to 3+ member carpools. Such a carpool may park in a reserved spot near the building of its choice and receives a fee discount as well. Persons registering as a carpool receive decals for each vehicle that may be driven by the carpool along with one pass which must be displayed by the car being driven on any given day. According to Bill Barr, despite these benefits, carpools seldom register in this way. Perhaps this lack of use is related to a lack of publicity, as it is only publicized once per year in a mailing that goes out to remind all those who held parking permits in the previous year that they need to renew. Other possible reasons why it is not often used are that it is not sufficiently convenient to establish a carpool, and that it is not practical for people with children. We will address these issues in our recommendations.

During the oil crisis in the 1970s, Dartmouth established a vanpool system in which employees could share the maintenance costs and the use of a college-owned van. This option was widely used at that time, but has steadily declined since then, at least partly because of a loss of financial incentives (high gas prices) and college subsidy for the program.⁴⁷

UPPER VALLEY CAR/VANPOOLING SERVICES

Free carpool matching is available through the Advance Transit office and also through the statewide Vermont Rideshare Program for commuters in Vermont and the Upper Valley – Lake Sunapee Region. The Rideshare Program offers a Guaranteed Ride Home Program as well, making carpooling options more feasible for those concerned with having a car available for

⁴⁶ Office of Mobile Sources, *Commuter Choice: Information for Employers*, 1998, (United States Environmental Protection Agency), 1 May 2000, <<http://www.epa.gov/oms/transp/comchoic/f98031.htm>>.

⁴⁷ All factual information in this section was relayed by William Barr of Dartmouth College Facilities Operations and Management during an interview, Apr. 2000.

emergencies. Registered users can call the Rideshare coordinator in the event of an emergency and the company will cover up to \$50 of the cost of emergency transportation. Vanpooling Loans are also an option for private companies through Rideshare. The Interest Free Vanpool Loan Program covers all but 10% of the initial cost of 7-15 passenger vans purchased by groups and businesses for work related commuting. The balance is paid within 48 months to the Vermont Public Transportation Association.⁴⁸

ALTERNATIVE CARPOOLING/VANPOOLING POLICIES: OTHER UNIVERSITIES

In order to increase ride sharing, particularly among commuting employees, many colleges and universities have created programs to help in carpool planning and to provide incentives for sharing rides. Emory University, which has more than 15,500 employees, already has 400 participating in their car and vanpool program. The University provides a rider-matching service through Parking and Community Services, and those participating in a carpool are given reserved deck or lot parking for \$100 per year, a guaranteed ride home for emergencies, and a tag for 12 free parking passes per year for days when it is necessary for members of the carpool to drive their own personal vehicle. Carpools with three or more members may park for free. Vanpools at Emory University are a group of 7 to 15 commuters who share the costs of operating the van. Several members of the vanpool get certified to drive the van. Vanpools with three or more eligible employees from the University, the Emory University Hospital, or the Emory Clinic receive free parking, a \$38.25 per month subsidy, a reserved parking space, a guaranteed ride home for emergencies, and a tag for 12 free parking passes per year.⁴⁹

In the process of performing an audit on the environmental implications of transportation at Princeton University, a committee was formed with the task of analyzing the campus-related sectors having the largest impact on emissions. In compliance with the Employee Trip Reduction Program measures called for under the Clean Air Act amendments of 1990, the Princeton University Ride Share Program (RSP) was formed. The RSP operates as a database of commuting employees living in different areas that are interested in forming car or vanpools.

⁴⁸ *Vermont Rideshare*, 1996-1999, LocalNet Communications, LLD, 4 Apr. 2000, <<http://www.CommunityInfo.COM/rides/>>.

This database is easily accessed on Princeton's web site or gopher, and both information and registration for the program are available by computer or by contacting the Employee Transportation Coordinator.⁵⁰

At the University of California, Irvine, a commuter can find a carpool partner on the internet. A group of carpoolers receives either one free parking permit or one Student Carpool Dollar, which can be used at local businesses. Five parking permits can be traded for two Student Carpool Dollars.⁵¹

At the University of Washington, Seattle, carpools can park for free if the driver and passengers all participate in the alternative transportation program and hold a U-Pass. The U-Pass program provides merchant and transportation discounts for faculty, staff, and students.⁵²

The University of Buffalo has a free rideshare program for students, faculty, and staff. The rideshare program uses PC-based geographic information software to match commuters who have similar points of origin and daily routines. It is sponsored by the Transportation Committee of the UB Environmental Task Force.⁵³

Stanford University pays people not to drive. As a part of the Clean Air Cash Rewards Program, Stanford offers employees up to \$144 per year not to drive to work and awards up to \$144 credit per person towards a carpool permit. Furthermore, the Guaranteed Ride Home program ensures quick ride services. When there is an emergency, a carpooling member can call transportation services and have access to a car in 15 minutes.⁵⁴

At the University of Michigan, there is a vanpool program for employees from five central locations, depending on the region where the employee lives. There is a \$65.00 monthly charge for the vanpool taken from vanpoolers' paychecks.⁵⁵

⁴⁹ *Community Services and Parking Regulations*, 1999, "Parking Regulations," Emory University, Dec. 1999, 4 May 2000, <<http://www.emory.edu/PARKING/regulations.htm#Partnership>>.

⁵⁰ Princeton Environmental Reform Committee (PERC), 1995, Environmental Audit of Princeton University: Chapter 9 - Transportation. Princeton University 1995, 15 May 2000, <<http://www.princeton.edu:80/~perc/Perchap9.htm>>.

⁵¹ *Student Alternative Transportation Incentives*, UC Irvine, 20 Apr. 2000, <<http://www.parking.uci.edu/student.htm>>.

⁵² DKS Associates, *University of Washington Transportation Master Plan*, 2000, University of Washington, 25 Apr. 2000, <<http://www.washington.edu/communtiy/cmp/cmp.html>>.

⁵³ *UB RideShare Program*, University of Buffalo, 19 Apr. 2000, <<http://wings.buffalo.edu/news/newsbureau/rideshare/>>.

⁵⁴ *Parking and Transportation Services: Clean Air Cash*. 2000, Stanford University, 8 May 2000, <<http://bontemps.stanford.edu/transportation/proginfo.html>>.

⁵⁵ Skora, Mike. *Plant Operations' Transportation Services: Vanpool*, 2000, University of Michigan, 16 Apr. 2000, <<http://www.plantops.umich.edu/transport/Vanpool.html>>.

Cornell's Transportation Demand Management Program provides the commuting option of ride sharing to employees through the "Commuter Connection," a listing of potential ride sharing employees found in the *Cornell Chronicle* and on the computerized CUINFO. For employees who do carpool, each individual is provided with twenty free one-day parking permits per year. Carpoolers also have emergency rides available and those with child or dependent care responsibilities are eligible for additional books of one-day parking permits for days when these responsibilities require them to drive single occupancy vehicles to campus.⁵⁶

RECOMMENDATIONS FOR DARTMOUTH: CARPOOLING/VANPOOLING

Based on our research, we think that Dartmouth could and should implement a number of carpooling and vanpooling policies to improve the viability of these more energy efficient modes of transportation. Dartmouth should begin by initiating a Rideshare program for employees and students – at least on-line and perhaps also by telephone. An on-line database accessible through the Dartmouth website would be likely to succeed at such a wired campus as this one. To foster interest for these programs and expedite the matching process, the College should organize monthly, or per term, zip-code meetings to connect those who live near each other.⁵⁷ With so many employees living outside Hanover and neighboring towns, these meetings would not only connect carpoolers but also serve a social function for those who live farther from campus. Similar meetings could be organized by daycare centers and schools, since many state the responsibility of children as a major factor contributing to single occupancy commuting. By connecting employees with common interests, Dartmouth could start a social network that would be more convenient for those with children and also decrease the amount of driving on campus.

In response to concerns over the viability of carpooling in the event of emergencies, Dartmouth should make its Vox fleet, those vehicles available for rent to other departments and organizations, available to those who carpool and who may have to leave campus without advance notice (see Alternative Policies: Other Universities for descriptions of Guaranteed Ride Home Programs). Adding alternative fuel vehicles, such as hybrids and electrics, into this fleet

⁵⁶ Wendt, William, *Cornell Transportation Demand Management Program*, Cornell University, 16 Apr. 2000, <http://eco.pdc.cornell.edu/Green_Programs/TDMP.htm>.

would lessen environmental impact. See “College Fleet” and “Alternative Fuel Vehicle” sections for specifics.

We also recommend that the College purchase a number of low-emission vans for vanpools of over 7 people and reinstate its past vanpooling program. Financial incentives, including subsidies, and driving certification should be made available through the College. The past success of this program shows that there is likely to be significant interest among commuters.

Parking policies should reflect Dartmouth’s dedication to reducing the environmental impact of driving. The College should make parking free and reserve priority parking for those who carpool. A limited number of free individual passes should be made available for employees who may, on occasion, be required to drive themselves to campus. With fewer people parking, the College will be able to convert campus lots to other uses, or avoid the construction costs of additional spaces. See “Parking Recommendations” for financial incentives.

WALKING/CYCLING

CURRENT POLICIES

Dartmouth encourages cycling and walking on campus over other modes of transportation. The relatively small size of the campus encourages these forms of transport, particularly among students. However, many students still drive from place to place on campus when rushed. Educational initiatives aimed at increasing student awareness of the environmental impacts of driving might reduce this tendency.

⁵⁷ Princeton Environmental Reform Committee (PERC), 1995, *Environmental Audit of Princeton University: Chapter 9 - Transportation*. Princeton University 1995, 15 May 2000, <<http://www.princeton.edu:80/~perc/Perchap9.htm>>. This was an Employee Education Program at Princeton.

Free bike registration and a student assembly sponsored Big Green Bikes Program, where students make use of a “common pool” of bicycles available throughout campus, attempt to make biking more prevalent. The latter program has not been extremely successful thus far,⁵⁸ but biking in general is still extremely popular among students. The College should continue to make the placement of ample bike rack space outside buildings a priority.

Bikes seem to be unpopular among college employees with only 19 out of 5,413 bicycles registered belonging to faculty, staff or professors. Safety and Security believes, however, that many employee bikes are unregistered.⁵⁹ The survey conducted by this class indicates that the main obstacles to biking and walking are weather, distance, hills, and time.⁶⁰

ALTERNATIVE WALKING/CYCLING POLICIES: OTHER UNIVERSITIES

Schools are encouraging cycling and walking as environmentally sensitive alternative modes of transportation. The new Master Plan for University of Colorado, Boulder states that the preferred modes of on-campus transportation are, in order: (1) walking, (2) bicycling, (3) transit, and lastly (4) driving.⁶¹ As in all other cities, traffic jams and lack of parking spaces encourage residents to figure out improvements in transportation. For more than a decade Boulder has attempted to change the transportation habits of its citizen through improved services, incentives, and public awareness.⁶² Incentive programs include the annual Walk and Bike Week. The "Green Bikes Program" offer users a free ride to their destination. The use of media plays a role in encouraging people to bike or walk more.

At Emory University, a campus wide program to encourage alternative options for commuters includes plans to move all parking to the outskirts of the campus, opening the central areas of campus to pedestrians with concrete walkways and more grassy space.⁶³ Emory's program to make the campus more easily navigated by pedestrians will also benefit cyclists.⁶⁴

⁵⁸ “Bike Thefts on the rise Spring Term,” *The Dartmouth* [Hanover] 24 Jun. 1998, <<http://www.thedartmouth.com/article.php?aid=199806240103>>.

⁵⁹ Roberts, Rebel, Sargent, Dartmouth College Department of Safety and Security, Email, 4 Apr. 2000.

⁶⁰ Survey conducted by Julia Ford via Blitzmail to 200 randomly chosen Dartmouth Employees, to which 91 staff and faculty responded, 17 Apr. 2000.

⁶¹ *The New Master Plan for CU Boulder, adopted by the Board of Regents*, 2000, University of Colorado, Boulder., 22 Apr. 2000, <<http://www.colorado.edu/cuenvironmentalcenter/blueprint/page5.html>>.

⁶² *Transportation Planning Newsletter*, 2000, University of Colorado, Boulder, 22 Apr. 2000, <<http://go.boulder.co.us/news/54/default.htm>>.

⁶³ Facilities management, *Campus Growth and Development*, 2000, Emory University, 5 Apr. 2000. <<http://www.emory.edu/WELCOME/campusgrowth.html>>.

⁶⁴ *Ibid.*

The University of Oregon, Eugene stresses the importance of shifting from a car culture to a bike culture. The Center for Appropriate Transport recommends that such a transition can be promoted by using creative ways to make people enthusiastic about alternative modes of transportation and to counter the powerful media's influence on the car culture.⁶⁵ Indeed, this is a part of the school's Sustainable Development Guidelines for the year 2000.⁶⁶

Cornell's Transportation Demand Management Program and In One Piece⁶⁷ program have made a commitment to maintain pedestrian-friendly, grassy areas on campus by not building any additional parking lots or garages on campus and instead limiting parking to what is already available.⁶⁸ The University is using this policy to encourage students, faculty and staff to find alternative modes of transportation to get to campus. Cornell's In One Piece Program also supports cycling by providing free bike registration and information on safe and legal biking.⁶⁹

RECOMMENDATIONS FOR DARTMOUTH: CYCLING/WALKING

We recommend that Dartmouth actively promote walking and biking through marketing strategies and public awareness. The more knowledge students have of environmental hazards, the more likely the success of alternative transportation systems. With this in mind, Dartmouth needs to encourage the use of bicycles and walking by appealing to public health and the environment. Similar to the University of Colorado's annual Walk and Bike week, the College should initiate incentive programs and events to emphasize the importance of our role as trustees of the environment and to encourage the shift away from our traditional car culture. Promotions should stress the practical benefits of using bikes as opposed to cars. Studies have shown that bicycles may be the cheapest and sometimes the fastest form of short distance travel (up to four miles or travel times of under 15 minutes).⁷⁰ Biking is also an excellent form of low-impact

⁶⁵ Jan VanderTuin, Center for Appropriate Transport, *Bike Culture*, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/transpo/janv.html>>.

⁶⁶ *University of Oregon Planning Office*, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/>>.

⁶⁷ Commuter and Parking Services, *In One Piece*, Cornell University, 16 Apr. 2000, <http://www.transportation-mail.cornell.edu/Commuter_and_Parking_Services/Level1/InOnePiece.html#anchor3450848>.

⁶⁸ Wendt, William, *Cornell Transportation Demand Management Program*, Cornell University, 16 Apr. 2000, <http://eco.pdc.cornell.edu/Green_Programs/TDMP.htm>.

⁶⁹ *Ibid.*

⁷⁰ Dougherty, Nina, "The Bicycle versus the Energy Crisis," *Bicycling*, June 1974, As reprinted by the US EPA, Office of Public Affairs (A-107).

exercise. To make cycling and walking more viable, both the College and the town should build bike paths into present and future development plans and consider closing more roads to cars in the center of campus. This would provide safer, more open pedestrian pathways and would make the campus more bike friendly.

PUBLIC TRANSPORTATION

CURRENT PUBLIC TRANSPORTATION: UPPER VALLEY

Advance Transit is the Upper Valley’s primary public commuter bus service and covers seven towns across New Hampshire and Vermont: Hanover, Lebanon, West Lebanon, Enfield, Canaan, White River Junction, Norwich, Wilder, Hartford, and Hartland.⁷¹ An independent service since 1984, Advance Transit covers six routes, the most popular being the Blue Free Fare Zone circling Canaan, Enfield, Lebanon, Hanover, and CRREL. Routes run on hourly or half-hour schedules from 5:20 a.m. until 6:45 p.m. Monday through Friday, with limited service on Saturdays.⁷² Recent additions to the Advance Transit system include two new Park and Ride shuttles: the Dewey Lot Shuttle, and the Thompson Arena Shuttle to Downtown Hanover. Van Chesnut, Executive Director of Advance Transit, estimates that roughly 50% of Advance Transit riders are associated with the College.⁷³ As a private, non-profit organization, Advance Transit relies on state grants, federal funding, property tax revenues, and subsidies offered by private institutions, such as the College, to cover operation costs. The Advance Transit has a diesel fleet of 18 buses that consumes 50 thousand gallons of fuel and travels half a million miles per year.⁷⁴

TABLE 2.8: BUS USE (PAST AND PROJECTED):⁷⁵

<u>Year</u>	<u>Riders</u>
1994	128,000
1999	245,000

⁷¹ Advance Transit Riders Guide, 1997, Pamphlet, effective 2 Sep. 1997.

⁷² *Vermont Rideshare Website*, 1996-1999, LocalNet Communications, LLD, 25 Apr. 2000, <<http://www.CommunityInfo.COM/rides/>>.

⁷³ Interview with Van Chesnut, Executive Director of Advance Transit, 11 Apr. 2000.

⁷⁴ *Ibid.*

⁷⁵ Interview with Van Chesnut, Executive Director of Advance Transit, 11 Apr. 2000.

2000 (est.)	300,000
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TABLE 2.9: CURRENT USE BY DARTMOUTH FACULTY, STAFF AND STUDENTS (2000 AT REPORT):⁷⁶

Route	Employees	Students
Blue Route	29%	15%
Fixed Routes	22%	11%

ALTERNATIVE POLICIES: OTHER UNIVERSITIES

Incentive programs are used in many schools to encourage the use of public transportation by commuting employees. The University of Colorado at Boulder offers bus pass discounts and a "Guaranteed Ride Home Program" for bus-pass holders. As a result, more bus passes are being purchased each year. The university's bus program has been very successful in the past two years. In 1998, 46% of faculty and staff parked on campus, but this number has dropped to 32% after the "Eco Pass" was introduced.⁷⁷ The Eco Pass program, which is a bus pass program for faculty and staff, has increased the use of transit by 88% since 1998 when the program was started, and has encouraged 157 employees have given up their parking permits entirely. In addition to regular buses, the University of Colorado has circulator shuttles running Monday through Friday from 7 a.m. to 7 p.m. The shuttle is sponsored by GO Boulder, a city transportation planning group. The shuttle also runs to downtown and to shopping centers.⁷⁸

An extensive shuttle service is also offered at the University of Georgia, Athens, and is funded 100% through a student transportation fee. With the large volume of riders, the bus system can operate at only \$0.28 per rider.⁷⁹

At the University of Wisconsin at Madison and Milwaukee, which are located in urban environments, the bus is the primary mode choice and is free with class registration. With a campus bus pass and an ID, students can take both intra-campus buses and local buses for free.⁸⁰

⁷⁶ *Ibid.*

⁷⁷ *GO Boulder Newsletter*, 2000, University of Colorado, Boulder, 23 Apr. 2000, <<http://go.boulder.co.us/news/54/54pg2.html>>.

⁷⁸ *University of Oregon's Transportation Systems Review Project*, 1996, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/transpo/BRWreport.html>>.

⁷⁹ *University of Georgia Campus Transit System*, University of Georgia, 1 May 2000, <<http://www.busfin.uga.edu/transit/facts.html>>.

⁸⁰ *University of Oregon's Transportation Systems Review Project*, 1996, University of Oregon, 20 Apr. 2000, <<http://darkwing.uoregon.edu/~uplan/transpo/TranspoRev.html>>.

UC Irvine and the University of Washington both have broad discount incentives for bus passes. At UC Irvine, students who do not purchase long-term parking permits get a 50% discount on bus passes.⁸¹ The University of Washington-Seattle heavily subsidizes their bus pass program.⁸² The University of Arizona subsidizes a bus pass for students at a \$650,000 annual cost. There are intra-campus shuttles running every 10 minutes between 7 a.m. and 8 p.m.⁸³

Emory University has created a subsidy program which provides eligible active full time or part time employees of the university with free monthly transit cards for the Metropolitan Atlanta Rapid Transit Authority (MARTA). In the event of an emergency, the employee is guaranteed a ride home. For Emory University students, affiliates and employees not eligible for the free MARTA pass, transit cards are available through the university at a reduced cost.⁸⁴

One of the most attractive features of public transportation at other universities and colleges is the extensive hours and route service they provide. The University of Michigan provides transportation and escort services for students. There is a Nite Owl Bus Service across campus during Fall and Winter semesters that runs every 15 minutes from 7 p.m. until 2 a.m. There's a DPS Escort Service for emergencies that is available 24 hours a day. Students may pay \$2 for a Night Ride, shared taxi service anywhere in Ann Arbor from 11 p.m. to 5:45 a.m. Monday through Thursday, 11 p.m. to 8 a.m. Friday, 7 p.m. to 8 a.m. Saturday, and 7 p.m. to 5:45 a.m. Sunday. There is a free Ride Home service from 2 a.m. to 5 a.m. from the library, and a free Glazier Ride service to the Glazier Way Green lot.⁸⁵

Cornell University has an extensive public transportation route available to students and employees of the University through the Tompkins Consolidated Area Transit. Buses that run on campus routes operate every 5 to 30 minutes from 4:45 a.m. to 2:30 a.m. Monday through Friday, 9:30 a.m. to 2:30 a.m. on Saturday and Sunday, and 8:30 a.m. to 2:30 a.m. on Sunday and Monday. Buses to and from the city run every half hour from 6:30 a.m. to 7:30 p.m. Monday through Saturday. Students can buy reduced priced OmniRide passes for \$60 per

⁸¹ UC Irvine Parking and Transportation Office, University of California, Irvine, 25 Apr. 2000, <<http://www.parking.uci.edu/studentat.htm>>.

⁸² The Draft Transportation Management Plan, 2000, University of Washington, 27 Apr. 2000, <<http://www.washington.edu/community/cmp/cmp.html>>.

⁸³ Sun Tran-UA Bus Pass Program, 2000, University of Arizona, 15 May 2000, <<http://parking.arizona.edu/alternative/suntran.shtml>>.

⁸⁴ Community Services and Parking Regulations, 1999, Parking Regulations, Emory University, December 1999, 4 May 2000, <<http://www.emory.edu/PARKING/regulations.htm#Partnership>>.

⁸⁵ Skora, Mike, *Student & Retiree Parking Operations, Parking Services*, 1999, University of Michigan, 16 Apr. 2000, <http://www.plant.bf.umich.edu/parking/options/Students_and_Retirees.html>.

semester or \$120 per year. There are routes that travel to the Ithaca bus terminal, to the Tompkins County Airport and to the mall.⁸⁶

Franklin Pierce College in New Hampshire provides an on-campus shuttle for its 1,495 students⁸⁷ plus faculty, staff and visitors from 7 a.m. to 8 p.m. Monday through Friday, 12 p.m. to 8 p.m. on Saturday, and 12 p.m. to 6 p.m. on Sunday, free of charge. A night time Safe Rides service is also available around campus on Friday and Saturday nights from 10 p.m. to 2 a.m. The college also runs a free shuttle service to Market Basket Plaza and Wal-Mart and Hannafords at 10 a.m., 1p.m. and 5 p.m. Monday through Friday, 1 p.m. and 5 p.m. on Saturday, and 1 p.m. and 4 p.m. on Sunday. There is shuttle service to the three area bus stations and to the two closest train stations at a cost of \$0.35 per mile plus \$5.15 per hour.⁸⁸

Hartwick College has both the Otsego Transit Service and the Oneonta Public Transit lines open to the students of the college. The Otsego Transit Service offers eight different routes that run at different times between 6 a.m. and 7 p.m. at a cost of \$1.00 for a fixed route and \$30.00 for monthly passes.⁸⁹ Oneonta Public Transit has five lines, most of which run from 7 a.m. to 6 p.m. and travel to area businesses in town at a regular cost of \$0.65.⁹⁰

RECOMMENDATIONS FOR DARTMOUTH: PUBLIC TRANSPORTATION

A number of improvements to the public transportation system of the Upper Valley would increase its use by Dartmouth commuters. Many of the staff and faculty who responded to our April survey cited the unavailability of public transportation in the towns they live in as their primary deterrent from its use. Public Transportation should be extended to include these towns, and due to the scattered nature of housing in these areas, should probably take the form of a park and ride system. The existing system should expand services on weekends for those, primarily students, interested in shuttling to shopping centers in West Lebanon. Even as limited

⁸⁶ *TCAT FAQ*, Tompkins Consolidated Area Transit, 16 Apr. 2000, <<http://www.tcatbus.com/TCATFAQ.html>>.

⁸⁷ Office of Strategic Analysis, *FPC Facts*, 1999, Franklin Pierce College, 16 Apr. 2000, <<http://www.fpc.edu/admin/fast/DOSA/facts.htm#Rindge>>.

⁸⁸ Campus Safety & Security, *Franklin Pierce College: Student Life*, Franklin Pierce College, 16 Apr. 2000, <<http://www.fpc.edu/studentlife/safety12.html>>.

⁸⁹ Otsego Transit Service, *Bus schedule*, Hartwick College, 16 Apr. 2000, <<http://www.hartwick.edu/community/busschedule.html>>.

⁹⁰ Oneonta Public Transit, Hartwick College, 16 Apr. 2000, <<http://www.hartwick.edu/community/opt.html>>.

a service as one running twice per day on Saturdays and Sundays from downtown Hanover to the central shopping areas in West Lebanon would probably reduce student driving significantly and offer services to first year students who aren't permitted cars on campus. This shuttle could be Dartmouth/Student Assembly sponsored or be incorporated into the existing Advance Transit System.

Dartmouth should subsidize the use of Advance Transit for employees and students that fall outside the free routes currently provided, as well as advertise the existing system. Advance Transit could market at zip code meetings and Dartmouth could stress the importance and availability of these services. To reduce the distance that many employees must drive each day to campus, Dartmouth should focus future development plans on providing low-cost housing closer to campus. Shuttles should run from Dartmouth housing to the center of campus, especially for housing developments over two miles from the center of campus.

CONCLUSIONS

CURRENT DARTMOUTH POLICIES AND RECOMMENDATIONS

Our review of Dartmouth's transportation programs suggests there is substantial scope for improving current policies and reducing the college's environmental impact. Dartmouth has adopted a number of policies to discourage driving on campus, such as reduced fees for carpoolers, the denial of cars to first-year students, and the emergence of a number of park and ride shuttles. The college does, however, need to recognize its responsibility as a leading institution to work harder toward sustainable transportation. The high quantity of energy consumed and the pollution produced by commuters coming to and from campus suggests that faculty, staff, and students lack attractive alternatives to single occupancy driving, that Dartmouth's existing policies remain under-promoted, and that the consequences to both public health and the environment are not fully understood by all. We recommend that Dartmouth adopt the following policies to promote public awareness and encourage alternative, low-energy, low-emission transportation among faculty, students, and staff.

- *Problem:* Faculty and staff live far from campus, where public transportation, walking, and biking are not feasible.

- *Solution:* Tailor development plans to move a larger number of faculty and staff closer to campus and provide them with shuttle access or carpooling/vanpooling services. Dartmouth should implement zip-code meetings where commuters are connected to those in their area and where transportation policies can be publicized and carpooling promoted.
- *Problem:* There are few incentives to use alternative transportation.
- *Solution:* A Cash Allowance Program offering financial incentives to those who do not drive single-occupancy vehicles to campus. Under this program, those who do drive are not punished by higher fees, but those that choose alternative transportation are rewarded. The college should offer a pay-by-the-day option to encourage walking and biking, should provide carpoolers with ideal parking spaces, and should subsidize public transportation outside the free ride zone of Advance Transit.
- *Problem:* Carpooling/vanpooling is not feasible for those with children or those who are concerned that they may have to leave campus during the day in the event of an emergency.
- *Solution:* Offer part of its vehicle fleet to carpoolers in case of emergencies. This fleet should include state-of-the-art low emission vehicles and should be available on campus. For those with children, the college should implement a program similar to zip-code meetings that connect parents whose children attend the same schools or daycares. A program such as this would be convenient to parents who may pick up a number of children only once rather than five days per week.
- *Problem:* Public transportation is available in only seven towns, whereas Dartmouth employees are scattered throughout the Upper Valley and beyond. Schedules and time constraints make public transportation inconvenient.
- *Solution:* Carpooling/vanpooling programs would provide an alternative pseudo transportation system for those employees living in more remote areas in the Upper Valley. Advance Transit could also target these areas with park and ride services. Shuttle buses to campus should be available to those living close-by, particularly in winter months where those who would normally walk or bike are tempted to drive. Advance Transit, or the College, should provide weekend shuttle services from the College to shopping areas in West Lebanon.

These policies should be implemented in such a way as to appeal to environmental sensitivity and the desire for convenience and financial benefits, and be extensively publicized to staff and faculty. Dartmouth should dedicate itself to reducing the driving associated with the college, do its share to alter opinions concerning alternative transportation, and promote environmental awareness of the combined impact of automobiles on public health, clean air, and global warming.

Combined with the steps that the College has already taken, these policies would make Dartmouth a leading institution in sustainable transportation and improve the quality of life for employees and students alike, making Dartmouth a more attractive place for prospective community members for years to come.

CHAPTER 3: DARTMOUTH COLLEGE VEHICLE FLEET

Dartmouth is located in semi-rural New Hampshire on a 265-acre campus; total enrollment is about 5,300 undergraduate and graduate students. While the central campus is only about a mile across, and students walk from class to class, extensive student activities off campus create a demand for a vehicle fleet. Additional vehicles are used for general and specified transport, and services and maintenance. In this report, we will review Dartmouth's vehicle choices and fleet management practices.

In managing the vehicle fleet, the college should consider the economic and environmental costs of energy use. Combustion of fossil fuel in gasoline-run vehicles contributes to the emission of CO₂ and other pollutants, which are damaging on a local and global level. The pollution from gas powered vehicles is a health risk; and gas vehicle emissions include a number of greenhouse gasses which contribute to climate change on a global level. Awareness of such environmental impacts, as well as diligent efforts to mitigate them is critical to Dartmouth both as a customer-attracting corporation and as a model institution. During the 1999 fiscal year, the college vehicle fleet used 108,172 gallons of gasoline at a cost of \$67,067 and 1,807,798,510 BTUs (See Table 3.1). The dollar value of this cost does not take into account the negative environmental and social impacts that are associated with gasoline combustion. According to Clifford Cobb's 1998 report, "The Roads Aren't Free: Estimating the Full Social Cost of Driving, and the Effects of Accurate Pricing," the environmental cost of burning a gallon of gasoline is \$1.60 in addition to the price currently paid for gas.⁵¹ Using this figure, the external cost (the environmental impact of driving not paid by the College) incurred by the Dartmouth fleet last year was \$173,075. The extent of these costs warrants a review of the current system.

Today, the 130-vehicle fleet is comprised entirely of gasoline run cars, trucks, and vans, which are purchased and maintained by independent departments. While a certain number of the college's vehicles are necessary to the goals of the college, a review of vehicle choices and

⁵¹ Cobb, Clifford W., *The Roads Aren't Free: Estimating the Full Social Cost of Driving and the Effects Of Accurate Pricing*, (San Francisco: Redefining Progress, 1998) 53.

management practices reveals two main areas for improvement. First, vehicle type and fuel choice should be replaced by more energy efficient technologies. Second, fleet management lacks central authority, and is therefore inefficient.

VEHICLE ENERGY USE

Currently, the Dartmouth College vehicle fleet contains 130 “over the road” vehicles, including 47 trucks, 59 vans, and 24 sedans. In addition, the College owns numerous tractors, trailers, and other pieces of equipment that use small engines. In this particular assessment of the fleet, only “over the road” vehicles have been examined because over the road vehicle information was most easily attainable and pertinent to the subject of the report. The characteristics of the fleet have been compiled in the chart entitled “Characterization of the Dartmouth College Vehicle Fleet” (Table 3.2). This chart follows the same model as the one found in the report “Dartmouth College Fleet Assessment Project” which was completed by Entropy Solutions Group in December 1995.⁵²

Data were collected through contact with the individual college department responsible for each vehicle. The vehicles have been organized according to which department owns them and are described in terms of color, year, make, model, type of vehicle, purpose served by the vehicle, and annual miles traveled. Most of these categories are self-explanatory; however, the purpose and annual mileage categories must be explained.

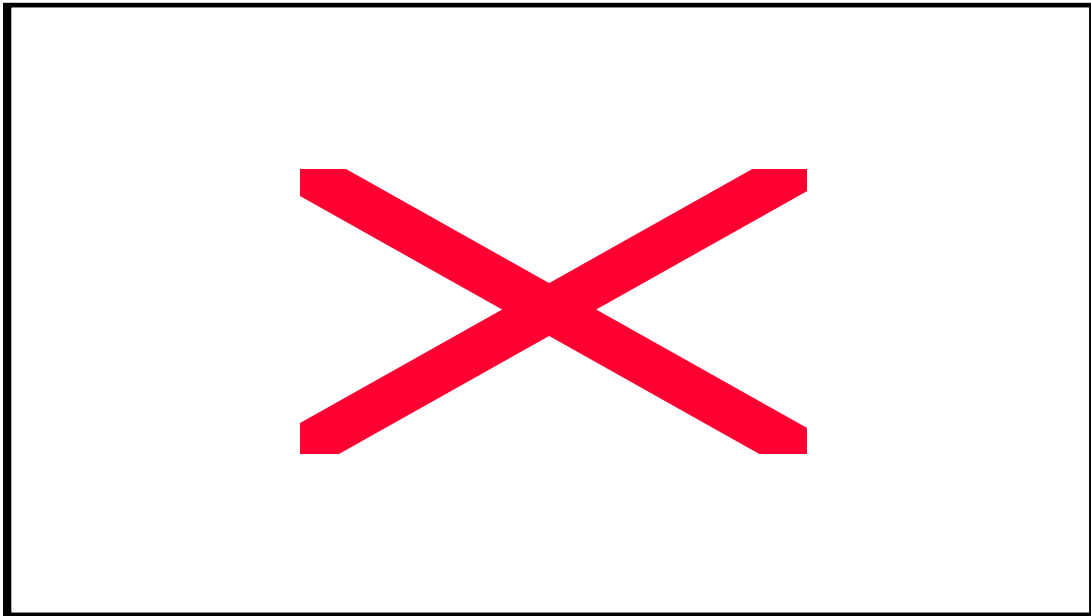
The four “purpose” classifications (adopted from the December 1995 report) are: general transport, designated transport, general service, and designated service. General transport vehicles “transport students to and from academic and extra-curricular activities”; designated transport vehicles “transport faculty and college employees to and from academic and extra-curricular activities”; general service vehicles are used by college employees “to carry out the day-to-day operations of the Department”; designated service vehicles are used by departments to “carry out specific tasks” and are generally “assigned to an individual or small group of

⁵² Entropy Solutions Group, *Dartmouth College Fleet Assessment Project: Final Report and Recommendations*, 2 Dec. 1995, Appendix A.

users.”⁵³ Currently, the Dartmouth College fleet contains 46 general service vehicles, 26 designated service vehicles, 47 general transport vehicles, and 11 designated transport vehicles. The annual mileage of each vehicle was obtained by asking the appropriate Department contact to provide the number of miles traveled by the vehicle over the past year. The ^^ symbol indicates that the vehicle is less than 1 year old and the number given is the total current mileage of the vehicle. The ^ symbol indicates that a total mileage was given by the department; the annual mileage was calculated by dividing the total mileage of the vehicle by the number of years it has been in use. From the information provided by the departments, we were able to calculate the average annual mileage for each type of vehicle. Trucks travel an average of 8,650 miles per year, vans travel an average of 9,393 miles per year, and sedans travel an average of 16,076 miles per year. These averages have been inserted in the chart where no information was provided by the department and are indicated by the * symbol for trucks, the ** symbol for vans, and the *** symbol for sedans. By combining data provided by the departments, we were able to estimate that the Dartmouth College vehicle fleet traveled a total of 1,346,554 miles last year with trucks traveling 406,552 miles, vans traveling 554,178 miles and sedans traveling 385,824 miles. The estimated average gas mileage for College-owned vehicles is 12.44 miles per gallon. This estimate may be slightly low because many of the mileage data we received were provided by those departments that use trucks.

Gasoline use at Dartmouth is divided up into departments, with each department being charged for the gas it uses. Facilities, Operations and Management (FO&M) is by far the largest consumer with their 1999 gas use accounting for 54.2% of the total gas used by the Dartmouth fleet that year. Some of the other large gasoline consumers include Safety and Security, Outdoor Programs, and the Athletic Department (See Figure 3.3).

⁵³ Entropy Solutions Group, *Dartmouth College Fleet Assessment Project: Final Report and Recommendations*, 2 Dec. 1995, 10.



Dartmouth pays a significantly reduced price per gallon because such large quantities of gasoline are bought annually. There are a couple of basic ways in which the Dartmouth Fleet could reduce its energy (gasoline) use. One is to consolidate or eliminate vehicles in an effort to lower total mileage and gas consumption and eliminate the production waste of these excess vehicles; the other is to use more efficient and/or alternative vehicles.

CURRENT MANAGEMENT

In addition to alternative technologies, fleet management has been identified as an area for improvement. The lack of central authority over Dartmouth's fleet is damaging to efficiency, and the concurrent financial burden incurred by the school translates into unnecessary environmental impact. At Dartmouth, although the act of purchasing vehicles is centralized, the decision to do so is done at the departmental level and is only limited by the department's budget. Therefore, departments will often buy vehicles that they need for specific tasks, but that are left unused otherwise. This departmental control results in a "feast or famine" cycle for the college fleet as a whole.⁵⁴ This means that at times there are more vehicles than are needed and

⁵⁴ Entropy Solutions Group, *Dartmouth College Fleet Assessment Project: Final Report and Recommendations*, 2 Dec. 1995, 11.

equipment sits idle, and at other times there are simply not enough vehicles to cover the demand. However, there are also situations when one department needs more vehicles and a different department has vehicles to spare, but no sharing occurs.⁵⁵ This leads not only to a lack of efficiency in terms of vehicle use, but also to a great deal of overlapping work for departmental fleet managers.

With travel managed by the individual departments, a large number of unnecessary miles are accumulated. For instance, trucks from central stores deliver materials and supplies to one place on campus and often return to Centerra (from where they operate located approximately 3 miles from campus) empty, while vans from other departments such as Dartmouth Dining Services (DDS) do the same. Other departments own vehicles that are used only at specific times to perform a specific task, resulting in an abundance of unnecessary vehicles. For example, Tucker's sedans are used by student volunteers to travel only in the Upper Valley and are generally not used in the evenings. Earth Sciences owns a large van which is used for 3 months during that department's Off-Campus Study Program but is used very little for the remaining 9 months of the year. FO&M operates the largest fleet of vehicles of any department, composed mainly of trucks that generally transport a single employee with tools to a work site. Some of these vehicles are used for maintenance emergencies but most are not used in the evenings. One suggestion for reducing these inefficiencies is to reduce the number of department-specific vehicles and create an expanded central fleet, that includes vehicles that several departments may access part-time, but no one needs all the time.

Currently Dartmouth has the Vox Fleet which is part of FO&M and consists of vehicles that are available for rent to departments and student organizations. The Vox Fleet includes two sedans and one passenger van. It is not heavily used although in recent years there has been an increase in the number of rentals. Most departments prefer to rent from outside rental agencies if they need a vehicle they do not have within the department. The major complaints against Vox are lack of available vehicles, difficulty in scheduling, and the expensive cost of renting from Vox. Currently the cost to rent from Vox is \$42/day and 5¢/mile for a passenger vehicle, and \$124/day and 10¢/mile for a fifteen-passenger van. The cost of renting a four-door sedan from

⁵⁴ Ibid.

Enterprise Rental, a private business located nearby, would be \$32.99/day with unlimited mileage at no extra cost. And lastly, a final problem with the current Vox fleet is that it does not always have the needed mix of vehicles.⁵⁶

RECOMMENDATIONS

The 1995 assessment of the Dartmouth Fleet suggested that the College could expand the Vox Fleet into a more effective centralized fleet. In order to do this, Vox could combine with the Outdoor Programs and Tucker fleets, for example.⁵⁷ This would supply more sedans and make five fifteen-passenger vans available. Vox could also make arrangements to rent cars from private agencies when needed. If Vox improved its reputation with the departments and became more service-oriented, for example, delivering vehicles when they were needed, departments could rely on this central fleet for vehicles that they did not need all the time.⁵⁸ This would also improve efficiency in terms of fleet management, as a central fleet manager could keep up to date information regarding acquisition, maintenance costs, and regulatory and environmental compliance. This would reduce administrative costs and responsibilities for each department.

It is not likely that the Dartmouth Fleet is going to make substantial reductions in miles traveled, but it is possible to reduce the number of vehicles used in this travel. The money saved by sharing vehicles could then be applied to purchasing electric or hybrid vehicles to perform certain tasks. Vans and sedans for faculty/staff carpooling could also be incorporated into the fleet and possibly employ these new technologies. In addition, emergency service vehicles could be added to ensure that using the consolidated Vox fleet does not lose the convenience of individual vehicles.

As mentioned above, another way to reduce the environmental impact of the Dartmouth fleet would be to use alternative forms of energy to fuel parts of the Vox fleet. Vehicle purchasing and fuel use choices need to be reviewed with environmental impact considerations taken into account. We will examine alternatives to gasoline-powered cars, such as electric and

⁵⁶ Entropy Solutions Group, *Dartmouth College Fleet Assessment Project: Final Report and Recommendations*, 2 Dec. 1995, 16.

⁷ *Ibid.*, 17.

⁸ *Ibid.*, 16.

hybrid cars and trucks, and their viability for fleet use. It is clear that the school's needs are conducive to more energy efficient transportation technologies than those currently used. Recommendations for improvement in this area constitute the main goal of this report.

Some jobs , many "general transport" automobiles, such as recruiting vehicles for the athletic department (DCAD), Tucker cars, and some Safety and Security vans could be replaced by hybrid vehicles. The hybrids use a combination of gas and electric motors, and get far more miles per gallon than conventional cars. Although some of these vehicles are more expensive than their gasoline-run counterparts, if the overall number of vehicles owned by the College was reduced through expanding the Vox fleet and eliminating some vehicles currently maintained by departments, there would be more money to spend on this technology. There are a number of current options explained in full in the upcoming "Alternative Fuel Vehicle" section of this report.

Several other leading universities have taken steps to reduce the impact of their vehicle fleets. The following examples are encouraging, because they demonstrate the feasibility of alternative vehicles at Dartmouth. Emory University has taken action to remove high-emission gas-powered vehicles from their fleet by replacing 44 of them with electric carts which can be recharged at various locations around campus. In addition, Emory has plans to bring five electric shuttles into the 30-bus fleet, of which 13 are fueled by compressed natural gas. Emory has received funding to help with the cost of this vehicle replacement through the Partnership for a Smog-Free Georgia and the Department of Energy's Clean Cities Program¹².

Cornell University has converted three of their mail delivery trucks to bi-fuel natural gas vehicles. By changing to an alternative form of fuel, these trucks have reduced emissions, saved energy, and have cost less to operate since an equivalent amount of natural gas to one gallon of gasoline costs 75¢ less¹³.

The University of Michigan has also incorporated alternative vehicles into their fleet by adding six Electric Ford Ranger pickup trucks to their 900 vehicle fleet: two in the grounds department fleet, two in the maintenance department fleet, one with the Occupational Safety and

¹² Seideman, Nancy, *Emory University Names New Alternative Transportation Director To Oversee Ambitious Program*, Emory University, Mar. 2000, 5 Apr. 2000, <<http://www.emory.edu/WELCOME/journcontents/releases/shawGU.html>>.

¹³ Kilmer, Greg, *Cornell Natural Gas Vehicles*, Cornell University, 16 Apr. 2000, <http://eco.pdc.cornell.edu/Green_Programs/NGV's.html>.

Environment Health fleet, and the last in the daily rental pool. Because these vehicles are primarily used on campus, the limited range before recharging does not cause any problems.¹⁴

As a leading institution, it is important that Dartmouth be on the cutting edge of energy-saving technology. The automotive industry predicts significant advancements in technology and reductions in the price of electric and hybrid electric vehicles over the next 5-10 year period. Such vehicles will become more available and affordable, and therefore more feasible for the College fleet. In the future, it is possible that the College fleet could be entirely “emissions free.” With this goal in mind, the college should remain at the forefront in terms of research and public education.

¹⁴ Skora, Mike, *Electric Vehicles, Transportation Services*, University of Michigan, 2 Apr. 2000, <http://www.plantops.umich.edu/transport/Electric_Vehicles.html>.

CHAPTER 4: ALTERNATIVE VEHICLES

Dartmouth College's Vehicle Fleet currently contains 130 vehicles, of which there are 47 trucks, 59 vans, and 24 sedans.⁵⁹ These vehicles release a frightening amount of toxins into the atmosphere each year and are less than 20% efficient, losing more than 80% of the energy supplied by gasoline to heat.⁶⁰ Something needs to change. Today, six automotive companies are taking the first steps in reducing these emissions, along with businesses and colleges around the country. The focus of their efforts lies in alternative vehicles, with hybrid electric and electric vehicles at the forefront of their research. These vehicles, endorsed by both the automotive industry and the national government, act as part of a feasible solution to the present danger of urban emissions. According to the Electric Power Research Institute (EPRI), substituting electric vehicles (EV's) for conventional vehicles (CV's) would lower emissions of non-methane organic gases by 98%, reduce nitrogen oxide emissions by 92%, and cut carbon monoxide emissions by 99%.⁶¹ EPRI estimates that, on a national scale, electric vehicles will produce 50% less carbon dioxide than their conventional counterparts.⁶²

These vehicles not only greatly reduce greenhouse gas emissions as compared to conventional vehicles, but they are also more efficient. Rather than losing more than 80% of the generated energy to heat, EV's lose only 10%, productively using the other 90%.⁶³ By 2003, 10% of the vehicles sold in California will be emission-free.⁶⁴ Thus, by 2003, many businesses, colleges, and residents will own EV's. Many already do. We have just entered the 21st century, and none of Dartmouth's vehicles meet the emission-free standards set by California. While we are not in California, Dartmouth College prides itself on being an environmental leader. How can we boast of this honor when 130 college-owned vehicles are emitting thousands of tons of greenhouse gases each year?

With the transportation sector's energy use growing at nearly the same rate as the Gross Domestic Product (GDP), and the fuel economy of conventional gasoline vehicles remaining at

⁵⁹ See Dartmouth College Fleet Section, Chapter 3.

⁶⁰ Thidemann Karl. Solectria Representative. Phone interview. 27 Apr. 2000.

⁶¹ Robert Q. Riley, *Electric and Hybrid Vehicles*, 15 Apr. 2000, <<http://www.rqiley.com/ev-tech.html>>.

⁶² *Ibid.*

⁶³ *Ibid.*

a consistently high level, automobile manufacturers are developing new environmentally conscious technologies. Hybrid-electric and electric vehicles are at the forefront of their research. The average fuel economy of light-duty vehicles, new cars, and light trucks over the last two decades has been stagnant. From 1983 to 1997, improved fuel economy technologies were adopted, yet the average fuel economy did not increase.⁶⁵ Instead, the technologies were counteracted by amenities such as weight and power, with the average light-duty vehicle horsepower and weight increasing by 55% and 13% respectively.⁶⁶ This resulted in only a 1% improvement in total on-road fuel efficiency for all light-duty vehicles from 1991 to 1995. These data illustrate the current automotive trend: the use of increased fuel economy to enhance vehicle performance and increase weight rather than increase miles per gallon (MPG).

Due to the increased demand for performance and size, the 1997 Annual Energy Outlook (AEO97) reference case forecasts virtually no improvement in light-duty vehicle fuel economy in the next two decades.⁶⁷ Instead, the AEO97 case emphasizes the necessity of alternative fuels and vehicles in lowering urban emissions and increasing fuel economy. The case, divided into three different categories (business-as-usual, efficiency, and high-efficiency/ low-carbon), states predictions for the implementation of these alternative technologies and their benefits to society.

The business-as-usual scenario predicts zero MPG improvement after 1997 for all light-duty vehicles,⁶⁸ and also incorporates a 26% increase in carbon emissions by 2010 and 33% by 2015. The efficiency scenario indicates that even with applied new technologies such as aerodynamic drag reduction, improved transmissions, engine friction reduction, and variable valve timing to conventional vehicles, the fleet (passenger cars, light-duty and heavy duty vehicles) MPG will still fluctuate around a low 28.2 MPG in 2015. Thus, rather than relying on these improvements to conventional gasoline vehicles, the business-as-usual scenario calls for the use of cellulosic ethanol as a blend with gasoline as a possible option, which would reduce greenhouse emissions by 2-3% more than the overall reduction in energy use.⁶⁹ This scenario includes in its projection the introduction of this ethanol-from-biomass technology in 2005. Yet,

⁶⁴ Joe Sherman, *Charging Ahead* (New York: Oxford University Press, 1998), 172.

⁶⁵ Interlaboratory Working Group, *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond*, (Oak Ridge, TN and Berkeley, CA: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory, 1997. ORNL-444 and LBNL-40533. Sep.) 21.

⁶⁶ *Ibid.* 21.

⁶⁷ *Ibid.* 5.

⁶⁸ *Ibid.* 21.

⁶⁹ *Ibid.* 3.

even under the normal fossil fuel based alternatives that use substantial amounts of coal for electricity, the efficiency scenario predicts that battery-electric vehicles are projected to decrease greenhouse gas emissions by 20% per mile by 2015.⁷⁰

The third scenario is the high-efficiency/ low-carbon projection. It also calls for substitution of lighter weight materials, aerodynamic drag reductions, and various transmission improvements, along with the combined effects of advanced lubricants, tires, and accessories.⁷¹ Together, these enhancements contribute to only a 2-5% gain in fuel economy.⁷² Taking these new technologies into account, the scenario predicts a 4% increase in CO2 emissions above 1997 levels by the year 2010, with the fleet average remaining as low as 27 MPG.⁷³ In 2015, because approximately 25-30% of the market share is projected to be comprised of hybrid vehicles, the MPG will greatly increase to an average of 50 MPG in this scenario.⁷⁴ The study also predicts gains in the hybrids themselves during the upcoming years through new technologies such as ultra high-efficiency electric motors and improved energy storage devices with high specific power and high in/out efficiency.⁷⁵

These forecasts show that significant strides in reducing fuel economy in the future will be offset by increased body rigidity, additional safety, power equipment, increased weight, increased horsepower, and torque of all conventional onroad vehicles. Therefore, any attention given to environmentally conscious forms of transportation should be directed towards the use of alternative fuels and vehicles.

ALTERNATIVE FUELS

Alternative vehicles are vehicles that run on fuels other than petroleum products. These vehicles have existed for nearly 100 years. Alternative fuel vehicles are important because gasoline and diesel-fueled cars, buses, and trucks are the greatest sources of air pollution in the U.S. As people are driving more today than ever, an alternative to common vehicles needs to be considered. Alternative fuels are cleaner because compositionally, they are less complex than

⁷⁰ *Ibid.* 29.

⁷¹ *Ibid.* 37.

⁷² *Ibid.*

⁷³ *Ibid.* 43.

⁷⁴ *Ibid.*

⁷⁵ *Ibid.* 34.

gasoline and when they are oxidized or burned, they burn “cleaner” with fewer emissions.⁷⁶ The incomplete combustion of a molecule in an internal combustion engine releases carbon monoxide, nitrogen oxide and other molecules in the exhaust. Electric vehicles have no internal combustion engine and therefore offer an even better alternative.⁷⁷ Another way in which alternative fuels outperform conventional gas is by evaporating less readily (the evaporation of fuel contributes to smog). Also, the use of alternative fuels reduces ozone-forming tailpipe emissions and would diminish our need to rely on and purchase overseas oil products produced outside of the U.S.

There are nine alternative fuel sources now being explored at different levels in the United States. The fuels are: P-Series fuel, propane, solar power, biodiesel, methane, natural gas, hydrogen, electric and ethanol. The P-Series fuel is a blend of ethanol, methyltetrahydrofuran (MTHF) and, pentanes; butane is added for blends that would be used in severe cold-weather conditions.⁷⁸ Ethanol and MTHF are both derived from renewable resources, such as waste cellulose biomass that can be derived from waste paper, agricultural waste, and urban and industrial wood waste.⁷⁹ P-Series fuel is currently available in vehicles offered by two major domestic auto manufacturers in mid-size sedans and minivans.⁸⁰ The environmental benefit of P-Series fuel is that it contains at least 60% non-petroleum energy content derived from MTHF (which is mostly biomass) and ethanol.

Liquid petroleum gas consists of a mixture of mainly propane, which is a by-product of natural gas processing and petroleum refining.⁸¹ Propane is produced domestically and is currently being used in 350,000 vehicles in the U.S, such as taxis in Las Vegas, buses in Kansas, and government cars. Propane has been used as a fuel for over 60 years in light and medium-sized vehicles.⁸² The benefits for using propane are a reduction in carbon build-up compared to gasoline and diesel powered vehicles, as well as a longer life span of spark plugs and engines. Special refueling equipment is needed to transfer the pressurized liquid from the storage tank to

⁷⁶ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <<http://www.afdc.nrel.gov/resources.htm>>.

⁷⁷ *Ibid.*

⁷⁸ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <<http://www.afdc.nrel.gov/altfuel/p-series.html>>.

⁷⁹ *Ibid.*

⁸⁰ *Ibid.*

⁸¹ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <<http://www.afdc.nrel.gov/altfuel/propane.html>>.

⁸² *Ibid.*

the vehicle to ensure that none escapes. Currently there is a lack of refueling stations for propane powered vehicles.⁸³

Solar energy is another alternative fuel. Solar cells trap and harness the energy of the sun's rays. This long-term possibility of operating a vehicle with solar power alone is very slim, but it may be used to operate certain auxiliary systems within the vehicles.⁸⁴ There is a very limited market for solar-powered vehicles, but the benefits are that it is 100% renewable and that it is a zero-emissions operating system.

Biodiesel is another alternative fuel. It is a cleaner-burning diesel fuel, which is made from natural, renewable sources such as vegetable oils. Just like petroleum diesel, biodiesel operates in combustion-ignition engines.⁸⁵ Essentially no engine modifications are required, and biodiesel maintains the payload capacity and range of diesel. The use of biodiesel in a conventional diesel engine results in a "reduction of unburned hydrocarbons, carbon monoxide, and particulate matter."⁸⁶ Biodiesel's physical properties are very similar to the diesel used in most trucks today. Emission properties, however, are better for biodiesel than for conventional diesel. Biodiesel fuel can come from new or used vegetable oils as well as animal fats.⁸⁷ These are domestic renewable resources, which are biodegradable and require minimal engine modification. Much of the current interest in biodiesel production comes from soybean producers faced with an excess of production capacity, product surpluses, and declining prices.⁸⁸ Methyl soyate, or SoyDiesel, made by reacting methanol with soybean oil, is the main form of biodiesel in the United States. Peanuts, cottonseed, sunflower seeds, and canola are other candidates for oil sources.⁸⁹ Biodiesel is relatively unknown and has several obstacles that are keeping it from being a widespread fuel source. It needs to be more accessible and less expensive to the public before it will become a competitive and practical alternative fuel.

⁸³ *Ibid.*

⁸⁴ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <http://www.afdc.nrel.gov/altfuel/sol_general.html>.

⁸⁵ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <http://www.afdc.nrel.gov/altfuel/bio_general.html>.

⁸⁶ *Ibid.*

⁸⁷ *Ibid.*

⁸⁸ *Ibid.*

⁸⁹ *Ibid.*

Natural gas is a mixture of hydrocarbons, but is mainly composed of methane. Methane is produced from gas well or in conjunction with crude oil production.⁹⁰ Natural gas is an important alternative fuel because it has clean burning qualities and has a domestic resource base. It is also commercially available to consumers. Methane is currently distributed throughout the United States in extensive pipeline systems.⁹¹ In short,

Exhaust emissions from NGVs [natural gas vehicles] are much lower than those from gasoline-powered vehicles. For instance, NGV emissions of carbon monoxide are approximately 70 percent lower, non-methane organic gas emissions are 89 percent lower, and oxides of nitrogen emissions are 87 percent lower. In addition to these reductions in pollutants, NGVs also emit significantly lower amounts of greenhouse gases and toxins than do gasoline vehicles.⁹²

Converting a vehicle from traditional gasoline to natural gas costs approximately \$3,000-\$5,000 for a light-duty vehicle. Bi-fuel vehicles, which run on both gasoline and natural gas, are also on the market.⁹³ There are over 1,300 fueling stations in the U.S. right now. Approximately 42 manufacturers (including Honda, Daimler/Chrysler, Ford, General Motors, Toyota, and Blue Bird) produce NGV's, which are used for a variety of vehicles such as passenger vehicles, buses, and industrial equipment.⁹⁴

Methanol is a liquid chemical that can be made from renewable resources such as biomass and municipal solid waste.⁹⁵ As a fuel, methanol and ethanol are very similar. More than 20,000 vehicles are using methanol, mostly in light-duty vehicles.⁹⁶ The United States produces 90% of the methanol used domestically, however, the fueling stations available are not very extensive.⁹⁷ The most important arguments for methanol use are the reduction of tailpipe emissions as compared to gasoline as well as reducing dependence on overseas products.

Hydrogen is currently being tested for use in combustion engines as well as fuel-cell electric vehicles. Although no distribution system exists for hydrogen transportation use, the ability to create the fuel from a variety of resources coupled with its clean-burning properties

⁹⁰ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <http://www.afdc.nrel.gov/altfuel/gas_general.html>.

⁹¹ *Ibid.*

⁹² The Natural Gas Vehicle Coalition, 30 Mar. 2000, <<http://www.ngvc.org/qa.html#trans>>.

⁹³ *Ibid.*

⁹⁴ *Ibid.*

⁹⁵ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <<http://www.methanol.org/methanol/fact/methanol.html>>.

⁹⁶ *Ibid.*

⁹⁷ *Ibid.*

make it a desirable alternative fuel.⁹⁸ Hydrogen is produced by electrolysis and “synthesis gas production from steam reforming or partial oxidation.”⁹⁹ Electrolysis actually harnesses electrical energy to split water molecules into hydrogen and oxygen. The benefits of hydrogen include: competition in a global economy that is already employing hydrogen technology, reduction of dependence on the Middle East for energy, the fact that it is a renewable resource and that it emits no toxins.¹⁰⁰ As with many of the alternative fuels, government funding for defense in the Middle East would be reduced, which would ease the trade deficit. The oil spills that have contaminated our water resources would be reduced with the decrease in demand and environmentally destructive oil-drilling would decrease as well.¹⁰¹

Ethanol is alcohol and is a clear, colorless liquid. Ethanol is penetrating the alternative fuel market through a product known as “gasohol.” Outlets for this resource are primarily in the Midwest, with approximately 50 filling stations in 12 U.S. states.¹⁰² Ethanol vehicles are currently available in cars, trucks and vans from manufacturers such as Dodge and Ford. The benefits that accompany ethanol vehicles are a reduction in the need for foreign oil supplies, the fact that it produces low emissions, and is a renewable fuel.¹⁰³

Electric cars are powered by batteries which store energy and come in a wide variety of types. The electricity is produced at power plants, the infrastructure of which EPRI describes as being 98% complete for fueling electric cars.¹⁰⁴ Electric cars have zero tailpipe emissions. They can be refueled at many sites, including homes, government facilities, businesses and garages while public charging areas are being developed.¹⁰⁵

The major elements of an electric vehicle are a motor, an electronic control module, a battery, a battery management system, a charger, a cabling system, a braking system, a body, and

⁹⁸ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <http://www.afdc.nrel.gov/altfuel/hyd_general.html>.

⁹⁹ *Ibid.*

¹⁰⁰ Office of U.S. Senator Harry Reid (Nevada), *Why Hydrogen? Ten Reasons Why the United States Should Switch to a Hydrogen Energy Economy*, 30 Mar. 2000, <http://www.ttcorp.com/nha/why_reid.htm>.

¹⁰¹ *Ibid.*

¹⁰² Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <<http://www.afdc.nrel.gov/afv/ethanol.html>>.

¹⁰³ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <http://www.afdc.nrel.gov/altfuel/eth_general.html>.

¹⁰⁴ Department of Energy, Alternative Fuels Data Center, 30 Mar. 2000, <http://www.afdc.nrel.gov/altfuel/ele_general.html>.

¹⁰⁵ *Ibid.*

a frame, plus fluids and lubricants.¹⁰⁶ The operation of an electric vehicle is nearly identical to the combustion engine of a conventional vehicle.¹⁰⁷ A main difference lies in the regenerative braking system of electric vehicles. The system begins working when the accelerator pedal is released or when the brake pedal is applied.¹⁰⁸ “This feature captures the vehicle’s kinetic energy and channels it through the electronic module to the battery pack. Regenerative braking mimics the deceleration effects of an internal combustion engine.”¹⁰⁹ Another difference centers around the batteries themselves: in an electric vehicle, battery cells, composed of electrodes, separators, terminals, electrolytes, and enclosures are grouped together into a battery pack and power the electronic drive systems.¹¹⁰ Currently five of the Big Seven Companies (Ford, Chrysler, General Motors, Toyota, and Nissan) are developing five different battery types: lead acid (PbA), nickel metal hydride (NiMH), nickel cadmium (NiCd), lithium-ion (Li+), and lithium-polymer.

HYBRID ELECTRIC VEHICLES

Hybrid Electric Vehicles (HEV's) are a crucial technological advancement in the fight to stop air pollution, in both the short and long run. From a technical standpoint, they are far more efficient than conventional vehicles. More importantly, they will be affordable and will not necessitate major changes in infrastructure like some other alternatives to conventional vehicles. As HEV technology develops, they could become an important alternative vehicle solution to the problem of vehicle emissions.

Hybrid Electric Vehicles are vehicles which draw from two different sources of energy: a gas engine and an electric motor. Thus far, designers have developed a variety of different systems to produce motive power with the two sources. They have also utilized a number of different types of engines and motors (e.g. fuel cells, lean burn gas engines, flywheels and ultracapacitors). All hybrids are built using one of two designs: a parallel configuration or a series configuration. The initial motivation for this design was to make up for the limitations of

¹⁰⁶ *Vehicle and Charging Technology*, 1998, Energia, 8 May 2000, <<http://www.energy.ca.gov/afus/ev/evtech.html>>,

1.

¹⁰⁷ *Ibid.*

¹⁰⁸ *Ibid.*

¹⁰⁹ *Ibid.*

¹¹⁰ *Ibid.* 2.

power supplied from batteries alone. “The inherent flexibility of HEV’s will allow them to be used in a wide range of applications, from personal transportation to commercial hauling.”¹¹¹

In a series configuration, a heat engine and a generator work together to supply energy to the battery pack, which in turn powers an electric motor. The motor is the only force driving the wheels, thus the engine never idles, greatly reducing emissions. As the technology becomes more sophisticated, smaller, more powerful generator systems are being developed, and the series configuration can supply ample performance while employing only the motor to supply motive energy while driving.¹¹²

In a parallel configuration, both the gas and electric power sources are directly connected to the wheels. This technology allows the car to utilize the different energy sources for different aspects of driving, such as accelerating and highway driving, to maximize efficiency in its fuel consumption. The parallel configuration has more power than a series HEV because both the engine and motor are directly connected to the wheels. Most parallel HEV's do not need a generator.¹¹³

Series and parallel hybrids have several distinct differences, but they utilize the same basic technological concepts to increase automobile efficiency. The combination of a gas and electric power source, along with other innovations, make HEV's approximately twice as efficient as conventional vehicles while greatly reducing emissions. Hybrid technology is not only promising because of the increased efficiency: the dual power source makes HEV performance comparable to that of conventional vehicles, and increases range.¹¹⁴

HEV technology has advantages over battery electric vehicles (EV's), an equally prominent alternative to conventional vehicles, for many similar reasons. Vehicles running solely on batteries can be very efficient, but current EV technology lacks the performance and range of a conventional vehicle. This is because the energy storage device, which must be "high energy" (since it is the car's only source of power) is quickly depleted. HEV's do not depend on their energy storage devices for the majority of the energy used while driving. Instead, they use a “high power” battery to work in conjunction with the engine, allowing both power sources to work at more efficient levels. The engine is responsible for producing energy to achieve long

¹¹¹Department of Energy, *What is an HEV?* 13 Mar. 2000, <<http://www.ott.doe.gov/hev/what.html>>.

¹¹²Robert Q. Riley, *Electric and Hybrid Vehicles*, 15 Apr. 2000, <<http://www.rqriley.com/ev-tech.html>>.

¹¹³*Ibid.*

¹¹⁴*Ibid.*

ranges (upwards of 800 miles), while the energy storage device provides additional power used to accelerate, climb hills, etc.¹¹⁵

Such technical aspects are crucial when considering the mid-viability of both alternatives. It is very difficult to make solid comparisons between HEV's and EV's and between HEV's and conventional vehicles for two reasons: hybrids come in a variety of different designs and they are very new.¹¹⁶ Alternative fuel vehicle technology is very promising, and will only improve with time. At present hybrids seem to be a solid combination of efficiency and practicality. They are almost as clean as electric cars and nearly match conventional vehicles in terms of performance. Moreover, they should be an affordable option in the mid-term future.

Another major contributing factor to the feasibility of hybrids is the fact that they will not necessitate large-scale changes in infrastructure. Such changes are holding back the widespread use of EV's (charging stations, repair facilities, battery recycling capabilities), because they take time and money to develop. However, we must recognize the potential value of zero-emission electric vehicles. Perhaps the smartest plan is to develop both technologies simultaneously, as improvements in one technology could give insight into the design options of the other. It seems pointless to say that hybrids or electrics are "better" than the other. Instead we must realize that they have different roles and both can be extremely useful in the long run.

Hybrid technology seems very promising, and with time it should only improve. Even the prototypes that have been developed to date seem to meet the present demands of consumers in a number of different areas. But despite the practicality of HEV's, there is still no guarantee that they will be widely accepted by consumers. Thus, the government has stepped in to help the introduction of hybrid technology, in light of the difficulties posed by the market system.

United States auto industry studies have reported that today's consumers are more focused on safety than on gas mileage when purchasing cars. Due to current environmental problems with air quality, especially in urban areas, regulations are beginning to require people to drive cleaner, more efficient cars.¹¹⁷ As these regulations become more prominent, people begin to realize the large-scale societal benefits of such vehicles. However, when it comes to making major financial decisions (such as purchasing a car), the vast majority of consumers are

¹¹⁵ Department of Energy, *Frequently Asked Questions*, 13 Mar. 2000, <<http://www.ott.doe.gov/hev/faqs.html>>.

¹¹⁶ Robert Q. Riley, *Electric and Hybrid Vehicle*, 15 Apr. 2000, <<http://www.rqriley.com/ev-tech.html>>.

¹¹⁷ Department of Energy, *Frequently Asked Questions*, 13 Mar. 2000, <<http://www.ott.doe.gov/hev/faqs.html>>.

quite skeptical about paying more, and sacrificing performance, for a car that does not carry direct or tangible benefits to them.

In an attempt to fight such skepticism, the Department of Energy (DOE) has made a strong commitment to helping HEV's achieve success in American automobile markets by launching the HEV Propulsion Program. The program brings together government and industry to encourage the development of new technology. The DOE (along with the National Renewable Energy Laboratory, NREL) is working with three major car manufacturers: GM, Ford and Chrysler. The program supplies 50% of the costs for the companies' HEV development programs. So far, several prototypes have been produced, and they hope to have "market ready HEV's" by the year 2003.¹¹⁸

There are three HEV prototypes that are already receiving much attention: the Toyota Prius, the Honda Insight, and the Ford P2000 Concept Car. The Prius is the first mass-produced hybrid to hit the market. It is a four-door sedan with a maximum speed of 100 mph and 101 horsepower combined between the two power sources. The Prius gets about 50 MPG and has an approximate range of about 600 miles. It has already been available in Japan for two years and there are over 30,000 on the road already. A newer model is slated to arrive in the United States during the summer of 2000. The U.S. version will achieve about twice the mileage of conventional cars and run 86% cleaner than the federally required fleet average. There is no market price available for this model.¹¹⁹

The Honda Insight has a fuel efficiency between 60 and 70 MPG. Its tank holds 10.6 gallons, which makes for a range of about 700 miles, and it should cost around \$20,000, depending on the specifics of the model. The Insight is a small, two-door passenger car with no roof rack and limited trunk space.¹²⁰

The Ford P2000 Concept Car is a five-passenger sedan. It gets about 63 MPG. The P2000 is not designed to operate in zero-emission mode (running solely off the batteries) unlike the Prius or the hybrids that GM is developing. The car is about 40% lighter than the 1997 Taurus, because it uses lexan, carbon fiber, titanium and magnesium in its design. The P2000's engine uses high-cetane fuel and is about 35% more efficient than a conventional car engine.

¹¹⁸ Department of Energy, *HEV Program Background*, 14 Mar. 2000, <<http://www.ott.doe.gov/hev/faqs.html>>.

¹¹⁹ @Toyota, *Specs worthy of a thousand words*, 10 Apr. 2000, <<http://www.toyota.com/afv/prius/specs.html>>.

¹²⁰ Honda website, 10 Apr. 2000, <<http://www.honda2000.com/models/insight/specs/specs9.html>>.

These design features have some drawbacks as well: gas could be very hard to find and the price of the car could be considerably higher.¹²¹

These three prototypes are an encouraging step toward widespread acceptance of HEV's. Though the technology has not been around for very long, hybrids have received attention from manufacturers, consumers and the government as well. They are emerging as the most sensible, viable alternative to conventional vehicles from a technological standpoint. With continued support and funding from programs such as the HEV Propulsion Program, car corporations are making this technology more practical and affordable for car users. Perhaps the most promising aspect of hybrid technology is the prospective improvement we will see in years to come. Other options will also be quite useful, but we must recognize the high value of hybrids in the battle to end vehicle emissions, especially in the near future. "Most experts agree that the car of the future, that has the same versatility as a conventional vehicle, will be an HEV of some kind. The energy density of electric batteries will never equal that of liquid or gaseous fuels, necessitating that these fuels remain a critical part of future vehicles to maintain the driving range and quick refueling found in today's conventional vehicles."¹²²

ELECTRIC VEHICLES

According to the [zero-emission-vehicle] mandate, which was a key piece of California's latest low-emission-vehicle plan, in 1998 two percent of the vehicles sold in California by the Big 7 (Ford, Chrysler, General Motors, Honda, Toyota, Mazda, and Nissan) had to be emission-free. In 2001, 5 percent had to be emission-free, and in 2003, 10 percent. [This means], with present technologies, battery-powered electric cars.¹²³

While this California mandate became more of a "recommendation" for the standards set in 1998 and 2001, it still holds for the 10% rule in 2003.¹²⁴ Perhaps though, what the mandate most clearly does is set the stage for battery-powered electric vehicles (EV's), which are seen by many automotive manufacturers to be the wave of the future. With 10% of the vehicles sold in

¹²¹ EV World, *Ford Unveils P2000 Hybrid Electric Car*, 1997, 10 Apr. 2000, <<http://www.evword.com/testdrives/fordev.html>>.

¹²² Department of Energy, *Frequently Asked Questions*, 13 Mar. 2000, <<http://www.ott.doe.gov/hev/faqs.html>>.

¹²³ Joe Sherman, *Charging Ahead* (New York: Oxford University Press, 1998) 21.

¹²⁴ *Ibid.* 72.

California in 2003 being EV's, these vehicles will dominate the low-emission sector of all major automotive companies. These cars are vehicles that depend specifically upon secondary batteries (rechargeable batteries) for their only source of energy.¹²⁵ They are more energy efficient, release fewer urban emissions, and have a more simplistic motor than conventional gasoline vehicles (CVs).¹²⁶ Approximately 46% of the electrical energy taken from the wall plug to charge electric vehicle propulsion batteries is delivered to the drive wheels as useful work; whereas, only 18% of the energy dispensed into the fuel tank as liquid motor fuel ends up at the drive wheels in conventional vehicles.¹²⁷ Even when the entire energy chain is considered (the stages through which energy from the primary source is converted to usable energy), studies generally conclude that battery-electric cars are about 10-30% more energy efficient than gasoline powered vehicles.¹²⁸ This is especially true when the recharging electricity source is itself emission-free such as in solar or wind-generated power.

Yet not only are EV's more efficient than CV's in the transfer of energy to the wheels as work, they are more efficient in their use of the energy. "An EV powertrain can convert energy stores into vehicle motion, just like a conventional vehicle, and it can also reverse direction and convert vehicle motion (kinetic energy) back into energy stores through regenerative braking."¹²⁹ In a CV, roughly 60% of the total energy spent in urban driving is expended simply to overcome the effects of inertia.¹³⁰ And "[a]ccording to Electric Power Research Institute (EPRI), substituting EV's for CV's would [also] reduce urban emissions of non-methane organic gases (NMOG) by 98%, lower nitrogen oxide (NO_x) emissions by 92%, and cut carbon monoxide (CO) emissions by 99%. In addition, EPRI estimates that, on a nationwide basis, EV's in the US will produce only half the CO₂ of conventional vehicles."¹³¹

Five of the Big Seven companies are currently working to meet the standard set by the California mandate, as is Solectria, a small automotive company specializing only in electric vehicles. Toyota is one such company. Under a Memorandum of Agreement (MOA) negotiated with the state of California, Toyota is required to produce and deliver 322 battery zero-emission

¹²⁵ Robert Q. Riley, *Electric and Hybrid Vehicles*, 10 Apr. 2000, <<http://www.sola>>, 2.

¹²⁶ Karl Thidemann, Solectria Representative, phone interview, 27 Apr. 2000.

¹²⁷ *Ibid.* 1.

¹²⁸ *Ibid.* 2.

¹²⁹ *Ibid.* 4.

¹³⁰ Thidemann.

¹³¹ Riley, 3-4.

vehicles prior to 2003.¹³² During 1998, Toyota delivered 359 RAV4-EVs, their version of an electric 4-door SUV, to customers, “And since the first vehicle was leased in November 1997, Toyota has placed over 507 RAV4-EVs on the road in selected markets nationwide.”¹³³ Their RAV4-EV has a high capacity nickel-metal hydride battery pack that achieves a top speed of 78 mph and has a range of 126 miles per charge.¹³⁴ It has a charge time of six to eight hours and boasts of its new inductive charging system.¹³⁵ Currently the RAV4-EV is in a test phase and is only available for fleet purchases of 10 vehicles or more by larger businesses or corporations such as electric utility companies, municipal governments, and private corporations.¹³⁶

General Motors offers a sleek, teardrop two-seater, the Generation 2 EV1, for lease to anyone who can meet the cost. Currently, however, the vehicle is available only at Saturn retail facilities in Arizona and California (Sacramento, San Francisco, LA, San Diego, Phoenix, and Tucson).¹³⁷ The Generation 2 EV₁ has two battery technologies, a high capacity lead acid battery pack and an optimal nickel-metal hydride pack.¹³⁸ Their high capacity lead acid pack has a range of 55-95 miles and charges from zero to 100% capacity in six to eight hours using a 220V charger.¹³⁹ Their nickel-metal pack has a range of 75-130 miles with the same charge time.¹⁴⁰ The Generation 2 EV1 also comes equipped with a 6.6 kW charger and a blended, regenerative braking system. Its top speed has been set to 80 mph, but the EV₁ holds the electronic vehicle land speed record at 183 miles per hour.¹⁴¹ The Manufacturer’s Suggested Retail Price (MSRP) for GM’s new electric sedan is marked at \$33,995. Leases are generally for periods of 36 months or longer and cost \$399-\$549 per month.¹⁴²

Ford has released the Ranger Electric, a two-door small-sized pick-up truck similar to the original Ford Ranger in all regards but with a greater degree of rugged durability and zero

¹³² *Toyota Announces Electric Vehicle Sales Record*, 11 Apr. 2000, <<http://www.toyota.com/times/product/docs/99rel/9904electric.html>>.

¹³³ *Ibid.*

¹³⁴ @Toyota, 10 Apr. 2000, <http://www.toyota.com/cgi-bin/top_frame.cgi?low_frame=%2fvehicles%2fvehicles.tmpl&data_frame=>>.

¹³⁵ *Ibid.*

¹³⁶ Diane, Toyota Representative, 25 Apr. 2000.

¹³⁷ John Anderlie, General Motors Representative, phone interview, 25 Apr. 2000.

¹³⁸ *GEN II – General Motors EV1*, 1999, General Motors Corporation, 10 Apr. 2000, <http://www.gmev.com/new/new_body_top.htm>.

¹³⁹ *Ibid.*

¹⁴⁰ *Ibid.*

¹⁴¹ *Ibid.*

¹⁴² Anderlie.

emissions.¹⁴³ The Ranger Electric comes in two battery options: the lead acid battery with a range of 58 miles per charge and the nickel-metal hydride improved version reaching a range of 100 miles per charge.¹⁴⁴ It has a top speed of 75 mph, 120 km/h, and a 112" wheelbase; with 90 horsepower capability producing 140 lbs. of torque, this truck has been said to surpass the rugged durability of a gasoline truck.¹⁴⁵ The Ford Ranger Electric is available for lease to individuals or companies through Ford dealerships and was the best selling electric vehicle in 1998.¹⁴⁶

Chrysler makes a four-door minivan known as the Electric Powered Interurban Commuter, or EPIC. This minivan features dual air bags, anti-lock brakes, regenerative steering, and power steering, brakes, and door locks and comes with the conveniences of air conditioning and heater, rear defrost, off-vehicle charger, and AM/FM radio.¹⁴⁷ The EPIC runs on an AC induction motor (100 peak/ 75 continuous horsepower), and a nickel-metal hydride battery which produces 336 volts in 28, 12V modules.¹⁴⁸ This nickel-metal hydride battery has a life of 4 to 6 years and a charging time of 6 to 8 hours with a 208/240-volt charger.¹⁴⁹ According to Mike Clement, expert on the EPIC and spokesperson for Chrysler, a unique feature of Chrysler's EPIC is its quick charge capacity.¹⁵⁰ With a 440-volt charger, the minivan can be charged to a 50-mile range in only 30 minutes.¹⁵¹ This quick charge capacity gives an entirely new dimension to the realm of electric vehicles in which a car can be recharged for the ride through town and home in just the time it takes to grocery shop or stop for lunch! The EPIC boasts a range of 80-90 miles and a top speed of 80 miles per hour.¹⁵² It is available for lease to business and government fleets in New York and California, and is generally leased for three years or 36,000 miles at a lease cost of \$450 per month.¹⁵³ Chrysler's predicted price of purchase is stated at \$45,000.¹⁵⁴

¹⁴³ Quinn Regis, Ford Motor Company Representative, phone interview, 26 Apr. 2000.

¹⁴⁴ Product Line (My 2000), Ford Motor Company, 10 Apr. 2000, <http://www.fleet.ford.com/get_started/alternative_fuel_vehicles/>.

¹⁴⁵ Regis.

¹⁴⁶ Ford Motor Company, 10 Apr. 2000, <<http://www.ford.com>>; and Regis.

¹⁴⁷ *EPIC: The 1999 Electric Minivan*, Chrysler Corporation brochure, 2000.

¹⁴⁸ *Ibid.*

¹⁴⁹ *Ibid.*

¹⁵⁰ Mike Clement, Daimler Chrysler Representative, phone interview, 26 Apr. 2000.

¹⁵¹ *Ibid.*

¹⁵² *Ibid.*

¹⁵³ *Ibid.*

¹⁵⁴ *Ibid.*

The EPIC has taken off with great success, as currently there are 45 in San Diego and 6 at the University of California in Los Angeles.¹⁵⁵ Chrysler's EPIC was integral in the making of the first all-electric run post office located in Harbor City which runs by a fleet of EPIC minivans.¹⁵⁶ Chrysler has been working efficiently to develop alternative fuel vehicles on all fronts, not merely electric, but has landed a great success as the first to solidify an actual minivan that is purely electric powered.

With their new vehicle, the Altra EV, Nissan has gone beyond the more limited lead acid and nickel-metal hydride batteries used in all other companies. Nissan has developed the first vehicle to use lithium-ion batteries, a larger version of those used in laptop computers and the most developed of all battery options for electric vehicles.¹⁵⁷ With an energy density nearly three times that of the original lead acid battery, the Altra EV's lithium ion battery is the first to offer long-range capacity as lithium ion can hold a far greater charge in a smaller battery.¹⁵⁸ Nissan's electric vehicle expert, Mark Perry, believes that the lithium ion battery is the only technology developed that will be able to meet the future demands of the California mandate in terms of efficiency and of the public in terms of long-range capacity.¹⁵⁹

The Nissan Altra EV is a four-seater with large cargo capacity that was designed to meet "real-world driving range" with a range of 80 miles per charge during combined city and highway driving.¹⁶⁰ Designed to be the most comfortable, driveable, attractive, and versatile of available electric vehicles, the Altra EV comes with many desired features.¹⁶¹ It has a synchronous motor which produces 13,000 rpm and 83 horsepower (62 kW) using an internal magnet of Neodymium-Iron-Boron alloy, a new high performance technology for electric vehicles, giving the motor an operating efficiency of 89 percent.¹⁶² The Altra EV also uses regenerative braking in their 4-wheel Anti-Lock Braking System to harness the kinetic energy created during braking and convert it to electricity for recharging the battery.¹⁶³ Its inductive battery charging has been made convenient for users using a plastic paddle easily inserted into

¹⁵⁵ *Ibid.*

¹⁵⁶ *Ibid.*

¹⁵⁷ Mark Perry, Nissan Representative, phone interview, 1 May 2000.

¹⁵⁸ *Altra EV*, Nissan brochure, 2000.

¹⁵⁹ Perry.

¹⁶⁰ Perry; and *Altra EV*.

¹⁶¹ *Ibid.*

¹⁶² *Altra EV*.

¹⁶³ *Ibid.*

the charge port, and its other features include: air-conditioning, AM/FM radio, and power windows and door locks.¹⁶⁴ The Altra EV comes equipped with all the other automobile amenities including a CD player and cruise control, and it contains the important safety features of dual air bags and steel side-door guard beams.¹⁶⁵

Because Lithium batteries are far more expensive than the more common lead acid and nickel-metal hydride batteries, Nissan has produced fewer cars in attempt to meet a greater standard. Currently, 60 Altra EV's have been placed into a 100% fleet market, or in other words, have been made available only for use in fleets by larger companies or corporations. They are being used in such places as the Los Angeles Department of Power and Water, and EV Rental, a branch of the Budget rental car company in the Los Angeles airport which uses only electric vehicles. The vehicles have been made available only for lease at a cost of \$599 per month of a three-year lease during which time all service is included by Nissan. Nissan has only made the vehicle available for lease due to the large expense of the battery and their desire to have the used batteries back for later use. They have agreed to have 127 in service by the year 2001 and are continuing to develop their state-of-the-art technology electric vehicle.¹⁶⁶

As the first company to begin development on electric vehicles, Solectria has been a forerunner of the movement despite their small size. Solectria has produced the Flash, a small pick-up truck designed for use in local areas. The Flash is not a street legal vehicle and is allowed only on private property, but the truck has proven extremely useful in its utilization at universities and power companies in Rhode Island. The Flash uses a 34kW AD induction system with twelve 12-volt modules and maintains a range of 45-60 miles.¹⁶⁷

Solectria has also produced the first electric vehicle available for sale. The Force is a compact sedan with three battery pack options. The first is a lead acid battery with a range of 50 miles, the second is a nickel cadmium battery with a range of 85 miles, and the most advanced is a nickel-metal hydride battery boasting a 105-mile range. The battery takes 10kW hours to recharge completely at a cost of only one dollar, equivalent to about three cents per mile. A battery charger is mounted in the sedan, a huge innovation given that with each of the other leading companies, those leasing a vehicle must purchase a charger which typically costs \$5,000.

¹⁶⁴ *Ibid.*

¹⁶⁵ Perry; and *Altra EV*.

¹⁶⁶ Perry.

¹⁶⁷ Thidemann.

Using a 110V outlet, the time to complete recharge is eight hours, but using a 220V outlet, the time is cut to between three and three and a half hours. (A 220V outlet is the same type as those used to run a clothes dryer and costs \$150 to install if not already built-in). The typical battery's life span is between 18 and 24,000 miles, but it depends on the degree of discharge each time it is used: the lesser the charge at each recharge after use, the longer the life of the battery. The average life of a battery is about three years and costs around \$2,000 to replace. The Force is run with a 42kW AC Induction (180V) and uses twelve 13-volt modules (lead acid).¹⁶⁸

The Force is now available to consumers to own at a cost of \$28,270, but comes with a federal tax credit of 10%.¹⁶⁹ With a significant tax credit upon ownership, this vehicle gives light to the positive direction the federal government has begun to turn with respect to alternative fuel vehicles.

From these new and steadily improving innovations by the country's leading car manufacturers, it is obvious that electric cars are a major focus of technological advancement to improve fuel economy. By 2010, annual sales of 75,000 battery electric cars and 150,000 battery electric light trucks are predicted by the 1997 Annual Energy Outlook reference case.¹⁷⁰ And by the same year, the Annual Energy Outlook case foresees 2 million battery-electric light-duty vehicles in operation.¹⁷¹ Accompanying this increased demand will be improved technology and economies of scale.¹⁷² "In the final analysis, mechanical systems are no match for the complex functional capabilities and the cost/benefits profile of electronic systems."¹⁷³

The present options from each of the major companies are limited but sufficient for the needs of a college campus the size of Dartmouth and are increasing rapidly on a daily basis. All major companies have joined the push for alternative fuel vehicles and continue to develop as the consumer demand rises. They have made their vehicles available for lease to prevent the cost to the consumer of new batteries and are doing their part to enhance the move towards a cleaner, safer environment.

¹⁶⁸ *Ibid.*

¹⁶⁹ *Ibid.*

¹⁷⁰ Interlaboratory Working Group, *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond*, (Oak Ridge, TN and Berkeley, CA: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory, 1997. ORNL-444 and LBNL-40533. Sep.) 17-20.

¹⁷¹ *Ibid.*

¹⁷² Riley, 5.

¹⁷³ *Ibid.*

EMISSIONS/RECOMMENDATIONS

Considering the size and subsequent environmental damage of the college fleet, Dartmouth must consider alternative fuel vehicles as viable substitutes for the vehicles it uses. At the present, alternative fuel technology is still very underdeveloped, but there are already cars on the market which meet the needs of many different college vehicle users. Based on these needs, and the specifications of different vehicles, we broke down the fleet into different categories. “General service vehicles” are for day-to-day uses, while “designated service vehicles” are used by departments for specific designated tasks. Currently there are 46 general and 26 designated service vehicles. On average, service vehicles travel less than 35 miles per day, and thus are replaceable by electric vehicles. “Transport vehicles” transport people and thus necessitate a higher range, so we focused on hybrids to replace this category. Beyond the specification of range, we looked at actual uses to determine the model of vehicle (vans, trucks, etc.). Available alternative fuel vehicles were matched with vehicles in these various categories, and compared in several different ways.

Table 4.1 (See below) presents a college vehicle and its hypothetical replacement, and estimates differences in gallons used, MPG, total energy used and total green house gasses emitted. In some cases the replacement vehicles differed from the cars they would be substituted for, but they seemed to fit the needs of that particular car user. See Chapter 3 for the annual mileages and further information on the College fleet. The MPG estimates came from the website <http://www.fueleconomy.gov/feg/cartablef.jsp>, and allowed us to estimate the gallons used annually by each car. This website also provided estimations for annual greenhouse gas emissions in tons, but estimates were not available for the prospective replacements. We used the GREET model estimation for reductions in GHG emissions by ton (43.1 % less for EV’s, and 51.1% less for HEV’s). In the case of conventional and hybrid vehicles, the gallons used translated into total energy used. For electric vehicles, to find the total energy, we converted the kilowatt-hours it took to power the battery to BTUs. We estimated the amount of charging it would take to go a certain distance, then multiplied that by the amount of BTUs per charge to find the total annual energy use.

The table was devised to demonstrate the feasibility of replacing college vehicles with electric and hybrid cars, and to demonstrate the drastic reductions in energy used and greenhouse emissions, which can be achieved with such substitutions. But even more important than the prospect of replacing college vehicles with alternatives already on the market, are the possibilities in years to come. Conventional vehicles are at the end of their life span and have been improved over time to be as efficient as possible. In contrast, HEV's and EV's are at the beginning of their life span and already are far more efficient than conventional vehicles. With time the technology will develop and eventually solve the problem of automobile emissions. These may be the first steps, but they are already vast improvements upon conventional vehicles.

Dartmouth stands to benefit in many ways from an investment in alternative fuel vehicle technology. It will set an example for other institutions, and hopefully encourage the acceptance of this crucial technology. Dartmouth can also help the infrastructure of the surrounding area by investing in charging stations or battery recycling facilities. These are very valuable changes.

As the college buys or leases new vehicles and phases out old ones, it should implement a program which would require alternative fuel vehicle technology to be considered. In years to come, feasible substitutes will become cheaper and easier to obtain. If strong, serious consideration is given to the alternatives, the college will certainly find cars which fit its needs at a very reasonable price. Eventually Dartmouth could phase out many, if not all of its conventional vehicles, and play a leading role in the battle against automobile emissions.

**TABLE 4.1 – ANNUAL MILEAGE, GALLONS, TOTAL ENERGY AND GREENHOUSE
GAS EMISSION CHART.**

CONCLUSION

The transportation industry is a major contributor to both energy consumption and pollution in the United States. In order to curb the damage being done by the high use of single-occupancy and energy-inefficient vehicles, there must be alternatives to today's prevalent modes of transportation. Dartmouth College claims to be an environmentally-friendly, "green" school, yet in recent years the college has made little or no attempt to limit the energy used or the pollution produced by vehicles driven on and around campus. This study assesses the energy used in transportation at the college. The recommendations we have made are starting points for reforming the current situation.

There are presently 2,494 employees of Dartmouth College working in Hanover and 2,245 vehicles commuting to campus. Through policy changes and incentives, we believe the college could reduce this number of commuting vehicles. Commuters primarily travel in single-occupancy, gasoline-powered vehicles because feasible alternatives are either not available to them, not well adapted to their needs, or because commuters are simply unaware of other options. We suggest providing a monthly transportation allowance in employees' paychecks concurrent with an increase in parking fees, and an option to pay by the day for parking. These changes would create a cash incentive for employees choosing to use an alternative form of transportation in their commute to and from campus. In particular, we recommend more highly visible programs of public transportation, carpools and vanpools to be advertised in print and electronically. As these programs expand, we suggest a move towards greater flexibility for employees with children in daycare and other special needs.

The college fleet consists of 130 conventional, gasoline-run vehicles for transport, maintenance, and other services. Management of vehicle purchase, fuel purchase, and maintenance is all handled departmentally. Having 28 departments managing their fleets independently creates inefficiencies. We suggest that centralized management with customer-based improvements and a common-use fleet could reduce the number of vehicles needed, save money, and reduce environmental impact. Given the amount and subsequent impact of the

energy use associated with transportation at the college, Dartmouth should also consider the promotion of alternative vehicles for both the college fleet and commuting employees.

In our review of the alternative vehicle industry, we found a number of electric and hybrid electric vehicles that may satisfy the needs of the college's departments today. Although technology is still underdeveloped, it is advancing rapidly. An increase in the use of alternative vehicles by 2010 will create opportunities for Dartmouth to incorporate these environmentally-friendly vehicles into the college fleet as they become less expensive and easier to obtain. Eventually, Dartmouth may be able to completely phase out conventional vehicles and act as a leading institution in the reduction of energy use.

Our review revealed several areas for improvement in the college fleet and commuter practices. While we are at a very exciting juncture in terms of alternative vehicle technology and public awareness, the appropriate changes will depend on the motivation of Dartmouth policy makers and commuters to commit themselves to this change. We hope that our research will serve as a useful starting point, and that Dartmouth can play a leading role in the movement towards sustainable transportation.

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