Reducing Fossil Carbon Emissions and Building Environmental Awareness at Dartmouth College

Summary and Recommendations

The following report was compiled at Dartmouth College by the students of Environmental Studies 50: Environmental Analysis and Policy Formation during the spring 2004 term. We were dealt the charge: "Identify the most effective environmental choices that Dartmouth College should make right now." In response, we selected the mission: "To reduce Dartmouth College's fossil carbon emissions." We believe this mission is most effectively met through implementation of the ideas recommended in this report. Our recommendations concern hybrid vehicles, renewable electricity purchasing, alternative fuels and wind energy production. By implementing our recommendations, Dartmouth College will reduce the amount of natural resources it consumes, reduce the pollution it generates, reduce the waste it creates, and reduce the degree to which it alters the biophysical environment. As an educational institution, it is Dartmouth College's responsibility to educate others about how it is reducing its fossil carbon emissions and encourage them to do the same. The recommendations that we present in this report are environmentally conscious, fiscally sound and strive to uphold the values embodied by Dartmouth College.

Introduction

Who We Are: Environmental Studies 50: Environmental Problem Analysis and Policy Formation is a class in the Environmental Studies Program at Dartmouth College designed to address local environmental problems. Students in the class work together in groups to formulate and justify policy measures addressing a local environmental problem.

Our Charge: "**Identify the most effective environmental choices that Dartmouth College should make right now**."

In evaluating our charge, we defined several aspects of our charge. We decided that an environmental choice is a choice between commodities or actions that impact both the biophysical and cognized environment. Additionally, an environmental choice is effective if it reduces our impact on the biophysical environment, or challenges the dominant social paradigm. Following these guidelines, we selected our mission.

Our Mission: "To reduce Dartmouth College's fossil carbon emissions."

Dartmouth College can reduce its impact on the biophysical environment in the following ways:

- Reducing the amount of fossil fuels that are consumed.
- Reducing the amount of pollution that is generated from fossil fuel consumption.
- Reducing the amount of waste that is created when extracting and consuming fossil fuels.
- Reducing Dartmouth College's demand to extract fossil fuels and contribution to global climate change, which alter the biophysical environment.

In our industrialized society, the reduction of fossil carbon exemplifies reducing our impact on the biophysical environment because our industrialized society was founded upon unconstrained consumption of fossil fuels. A social paradigm currently exists that allows for inappropriate amounts of fossil carbon (also known as CO_2) to be produced and emitted around the world. This social paradigm is manifested at Dartmouth College.

Simply put, Dartmouth College must take steps to reduce its impact on the environment. We provide the college with a number of effective ways to reduce its CO_2 emissions. Implementation of our recommendations would demonstrate that Dartmouth can be a leader in environmental awareness. The several options outlined in this report show that if Dartmouth makes a commitment to acting upon our recommendations, the rewards will be substantial. These rewards achieve our mission of reducing Dartmouth's CO_2 emissions and improve Dartmouth's reputation, intellectual atmosphere and capacity as an educational institution.

Overall Recommendations

1. Replace Selected Vehicles with Hybrid Alternatives (Refer to Chapters 6 to 9 of the Report).

Timeline: By 2009, replace all 16 Tier One vehicles.
Savings:

- CO_2 Emissions Reductions: 138 metric tons of CO_2 emissions per year; 397 metric tons of CO_2 emissions over the vehicles' lifetimes.
- Gasoline Reductions: 15,091 gallons of gasoline per year; 43,300 gallons of gasoline over the vehicles' lifetimes.
- Cost Savings: $23,314 per year; $70,314 over the vehicles' lifetimes.

2. Examine Energy Purchasing Portfolio (Refer to Chapters 11 to 16 of the Report).

Timeline: By June 24, 2004 (first day of summer term), Dartmouth College begins negotiations to arrange a contract with an electricity supplier that calls for a specific percentage of purchased electricity to be generated by renewable resources.
Savings:

- For Five Percent Renewable Energy: for every $1,000 spent, 7.3 metric tons of CO_2 emissions would be saved using wind; for every $1,000 spent, 54.6 metric tons of CO_2 emissions would be saved using biomass and small hydroelectric.
- For 100% Renewable Energy (Frontier Partnership): for every $1,000 spent, 37 metric tons of CO_2 emissions would be saved. A total of 14,210 metric tons of CO_2 emissions would be saved, a 20% reduction of CO_2 emissions.

3. Explore Option of Biodiesel (Refer to Chapters 17 to 19 of the Report).

Timeline: As biodiesel becomes more affordable, Dartmouth conducts an in-depth study of using biodiesel blends in diesel engines and off-campus heating.
Savings: For every $1,000 spent, between 5.3 metric tons and 6.2 metric tons of CO_2 emissions would be saved.

4. Explore Option of Wind Energy (Refer to Chapters 20 to 26 of the Report).

Timeline: By spring 2005, Dartmouth assesses the suitability of its land holdings for the placement of wind farms.
Savings: To be determined by assessment.

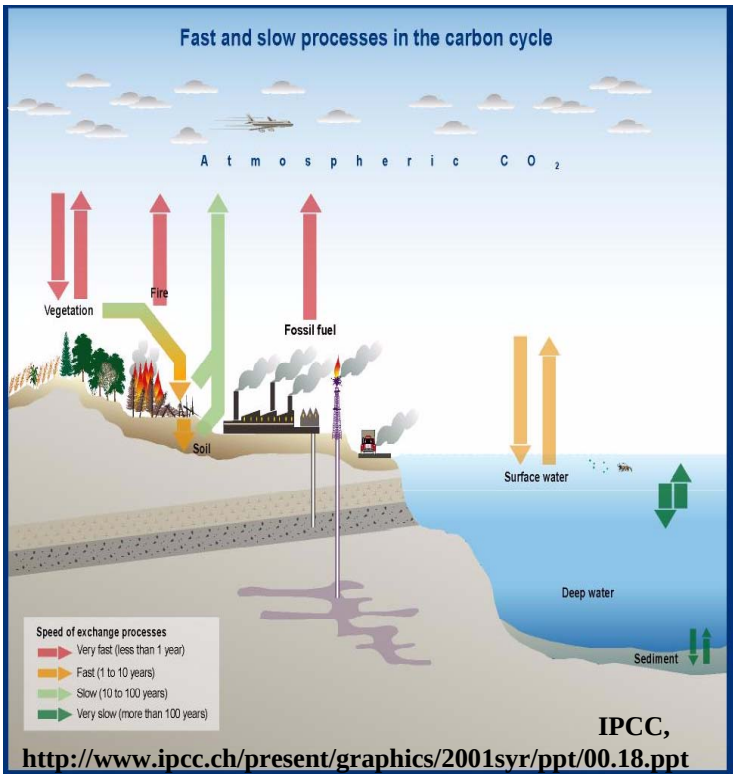
5. Educate the Student Body and the Broader Community (Refer to Chapter 28 of the Report).

Timeline: Ongoing.
Savings: The CO_2 emissions savings resulting from education have the potential to be much larger than the CO_2 emissions savings from any one of the above recommendations.

Justification for Change

Fossil carbon is one of many forms of carbon present on Earth. It is emitted during the combustion of fossil fuels. Currently, human activities are emitting a large amount of fossil carbon into the atmosphere, which is altering the balance of the global carbon cycle. This cycle is shown in Figure 1. The addition of fossil carbon to the atmospheric reservoir is causing changes to Earth's climate. These changes take place because CO_2 is a greenhouse gas. CO_2 emissions are linked to emissions of sulfur oxides, nitrous oxides, and many other atmospheric contaminants which also have adverse effects on the environment (see Chapter 2 for more information).

Figure 1: The Carbon Cycle



IPCC, http://www.ipcc.ch/present/graphics/2001syr/ppt/00.18.ppt

An international treaty for the reduction of CO_2 emissions known as the Kyoto Protocol was developed in 1997. It called for individual CO_2 emissions limitations and a legally binding agreement to meet those set standards. Despite the fact that the United States represents 38% of the global greenhouse gases emissions, the Bush administration decided in 2001 that the United States would not participate in the Kyoto agreement.

United States air pollution policies have traditionally been soft or non-binding, including voluntary programs, fiscal subsidies and an early action domestic emissions credit program. This is largely due to the influence of the energy industry in the United States. Since the United States withdrawal from the Kyoto Protocol, non-governmental organizations (NGOs) including Friends of the Earth, Greenpeace USA and the Sierra Club have pushed for compliance. As a result of NGO lobbying, many corporations have vowed independently to decrease their CO_2 emissions.

Dartmouth College emits large amounts of CO_2 by consuming fossil fuels. In 2002, Ritchie King, the Global Reporting Initiative Intern for Larry Litten, conducted an extensive analysis of Dartmouth's consumption of fossil fuels. According to his report, the primary sources of Dartmouth's CO_2 emissions are transportation, heating and electricity. The

report determined that in 2001 the college emitted roughly 65,000 metric tons of CO_2, and in 2002 the college emitted roughly 70,000 metric tons of CO_2.

Reducing Dartmouth College's CO_2 emissions addresses our charge to "Identify the most effective environmental choices that Dartmouth College should make right now." It is imperative that Dartmouth College join the movement started by other countries, states and universities by becoming a leader in the fight against global climate change.

In our report, we examine ways that Dartmouth College can make technological changes to reduce its CO_2 emissions. By making the technological changes recommended in this report, Dartmouth is demonstrating a commitment to reducing its CO_2 emissions. Another way that the college can reduce its CO_2 emissions is by changing the behavior of people who use the technology that emits CO_2 because conserving the consumption of fossil fuels reduces CO_2 emissions. These behavioral changes can easily prove to be more rewarding than any technology based program that the college can implement.

Dartmouth also has the opportunity to educate the student body and the surrounding community about their environmental choices. There are many ways in which Dartmouth can incorporate environmental education into its implementation of our recommendations. Taking into consideration Dartmouth's mission as an educational institution and the tremendous potential for further environmental rewards, we believe that these educational opportunities should be vigorously pursued.

The Environmental Studies 50 class evaluated many possible courses of action for the college to take in order to meet our objectives. The areas that we believe to be the most promising in both economic and educational terms are hybrid vehicles, electricity purchasing, alternative fuels and wind energy production. While all of our recommendations are feasible options for Dartmouth College, we wish to clarify that some options will be more easily and effectively implemented than others. The switch to hybrid vehicles is a very straightforward move that Dartmouth can make immediately in order to reduce its CO_2 emissions. A switch to renewable electricity purchasing can significantly reduce Dartmouth's CO_2 emissions. While its cost may be a deterrent, it is clear that the money spent on this option will effectively reduce the college's impact on the environment. The pursuit of alternative fuels is an option that while requiring a small monetary commitment from the college can have great rewards. This option needs more research before implementation. Similarly, the pursuit of wind energy is an option that has a promising future. Research will most likely show that Dartmouth can produce wind energy on one of its land holdings. It is important to realize that there are many educational benefits linked to these recommendations and these benefits should not be underestimated. A summary of the above recommendations follows.

Hybrid Technology

Dartmouth College currently has a fleet of 145 on-road vehicles, only two of which are hybrid-electric vehicles (hybrids). Dartmouth has the potential to significantly reduce CO_2 emissions from the consumption of fossil fuels through a conversion of select vehicles to their hybrid equivalents. We analyzed the vehicles used by each department and determined that the highest priority vehicles for conversion to hybrids would be certain vehicles used by Safety and Security, the Dartmouth College Athletic Department, Vox Car Rentals and Facilities, Operation and Management. We chose these vehicles based on the cost of switching to hybrids and their potential for CO_2 emissions reduction, but we encourage all other departments to make the switch as well.

Toyota, www.prius.com

Hybrids use a combination of an internal combustion engine and an electric motor to reduce fossil fuel emissions without sacrificing the performance of the vehicle. Rather than plugging the vehicles in to charge the electric motor, the energy captured from braking is used to recharge the electric battery while driving.

The two hybrids that we recommend are the Toyota Prius and the Ford Hybrid Escape. Both vehicles are regular production models and are covered by full factory warranties. The Toyota Prius is a mid-size sedan slightly smaller than the Toyota Camry, but larger than the Toyota Corolla. With combined city and highway gas mileage of 55 miles per gallon (mpg), the Toyota Prius would cut in half the amount of CO_2 currently emitted by most of the sedans Dartmouth owns. The Ford Hybrid Escape is the same as the conventional Ford Escape, but with gas mileage of about 35 mpg for city driving. The Ford Hybrid Escape may replace any sports utility vehicle (SUV), truck, minivan or van where an SUV of the Ford Hybrid Escape's size is sufficient.

Our recommendations for Dartmouth are outlined on the following page. The first tier recommendations would reduce CO_2 emissions by 166 metric tons while saving Dartmouth $70,100 in fuel costs each year. The second tier recommendations would reduce CO_2 emissions by 11.07 metric tons per $1,000 spent while the third tier recommendations would reduce CO_2 emissions by 0.76 metric tons per $1,000 spent.

Switching these select vehicles to hybrids has the potential to reduce Dartmouth's CO_2 emissions, save money, and perpetuate Dartmouth's reputation as an educator throughout the United States. No other college has made a large-scale switch to hybrids.

Hybrid Recommendations

Primary Recommendations (Tier One)

Safety and Security

- Replace Cruiser 2, the Chrysler Voyager due for replacement this year, with the Ford Hybrid Escape. This would yield an annual cost savings of $7,200 in fuel expenditures and an annual reduction of Dartmouth's CO_2 emissions of 41 metric tons. This translates to a net present value for the switch of $12,500 over the two-year lifetime of the vehicle.
- Replace Cruiser 1, the conventional Ford Escape due for replacement next year, with the Ford Hybrid Escape. This would yield an annual cost savings of $7,200 in fuel expenditures and an annual reduction of Dartmouth's CO_2 emissions of 41 metric tons. This translates to a net present value for the switch of $11,000 over the two-year lifetime of the vehicle.
- Replace the Guard Truck, the 2002 Ford Ranger pickup truck due for replacement in 2005, with the Ford Hybrid Escape. This would yield an annual cost savings of $860 in fuel expenditures and an annual reduction of Dartmouth's CO_2 emissions of five metric tons. This translates to a net present value for the switch of $1,500 over the four-year lifetime of the vehicle.

Dartmouth College Athletic Department

- Replace each car in the current fleet of the 2002 Toyota Camry with the Toyota Prius. Over the five-year life of these vehicles, there will be a 90 metric ton reduction in the emission of CO_2. Each year, there will be cost savings of $3,090 in fuel expenditures for the fleet.

Vox Car Rentals

- Replace vehicles Vox 5, Vox 7, Vox 9 and T-5 with the Toyota Prius. This switch will save $16,200 and 68 metric tons of CO_2 emissions over their lifetimes.

Facilities Operations and Management

- Replace the Ford Taurus Sedan with the Toyota Prius immediately. Replace the Buick Park Avenue Sedan with the Toyota Prius and Subaru Forester with the Ford Hybrid Escape when they are retired. These replacements will yield an annual 11 metric ton reduction in CO_2 emissions and lifetime savings of $21,900.

Secondary Recommendations (Tier Two)

Vox Car Rentals

- Replace vehicles T-2, T-3 and T-4 with the Toyota Prius. This switch will cost $1,450 and save 16 metric tons of CO_2 emissions over their lifetimes.

Tertiary Recommendations (Tier Three)

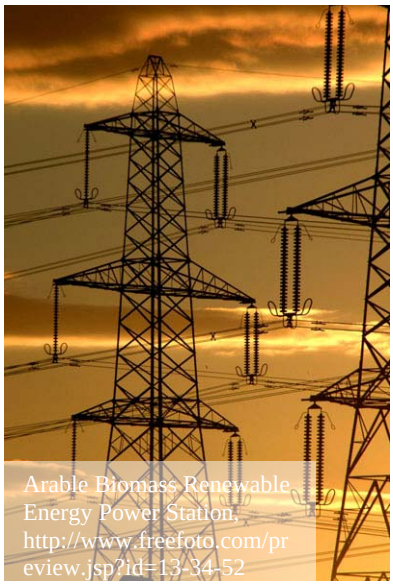
Facilities Operations and Management

- Replace the 15 targeted FO&M pickup trucks with equivalent Chevrolet Hybrid Silverado pickup trucks. These replacements will yield an annual 15 metric ton reduction in CO_2 emissions and cost approximately $19,700. For every $1,000 spent, 3.8 metric tons of CO_2 emissions will be saved.

Electricity Purchasing

Currently, Dartmouth's purchased electricity is generated by burning fossil fuels or utilizing nuclear or renewable technologies. By purchasing renewable electricity, we can offset CO_2 and other emissions produced by utility companies.

Dartmouth has several options for purchasing renewable electricity. Each option incorporates different percentages of renewable sources and results in different amounts of emissions reductions. The primary options presented in this report are listed below. A table summarizing the economic and environmental benefits of each plan is on the following page. Note that the economic and environmental benefits of a ten percent reduction in overall electricity use are included in these tables as an indicator of how a small change in behavior can substantially reduce CO2 emissions. Most of the below options work with the supplier Constellation NewEnergy, and they are all judged in comparison to the $3,084,000 that Dartmouth spends currently on purchased electricity (minus certain fees which cannot be judged until an actual contract is put into effect).



Arable Biomass Renewable Energy Power Station, http://www.freefoto.com/preview.jsp?id=13_34_52

Constellation NewEnergy offers a 100% renewable blended option. This option would provide Dartmouth electricity at a rate premium of $0.018 per kWh, leading to an annual cost increase of $759,400.

Constellation NewEnergy's Frontier Partnership is another option that is equivalent to purchasing 100% of electricity from renewable sources by 2008. The fixed rate offered by the Frontier Partnership is $0.08 per kWh of electricity, with a $386,910 cost increase. This cost increase will likely be offset overtime by increasing electricity rates (see Table 1 for more information).

Constellation NewEnergy also offers a 50% renewable blended product option, which would guarantee that 50% of Dartmouth's purchased electricity came from renewable sources. Dartmouth would buy its electricity for a premium of $0.015 per kWh, leading to an annual cost increase of $325,500.

The final option is to purchase five percent renewable electricity directly from local wind, biomass and small-scale hydroelectric projects through either Constellation NewEnergy or New Wind/Community Energy. For wind-generated electricity, Constellation NewEnergy offers a rate premium of $0.045 per kWh, leading to an annual cost increase of $97,640. For biomass and small-scale hydroelectric electricity, Constellation NewEnergy offers a rate premium of $0.006 per kWh, leading to an annual cost increase of $13,020.

Electricity Recommendations

Table 1: Financial Costs

	Renewable Electricity (%)	Total Electricity Billing	Annual Total Cost	Cost (%)	Cost (Per kWh)	Cost (Per Renewable % Point)
Dartmouth's Purchased Electricity (minus fees)	0.00	$3,084,000	$0.00	0.00%	$0.0711	$0.00
100% Renewable Estimate (Constellation)	100.00	$3,844,000	$759,400	24.6%	$0.0886	$7,594
50% Renewable Estimate (Constellation)	50.00	$3,410,000	$325,500	10.6%	$0.0786	$6,509
10 Year Frontier Partnership (Constellation)	100.00	$3,472,000	$386,900	12.5%	$0.0800	$3,869
5% Renewable (New Wind)	5.00	$3,183,000	$97,640	3.17%	$0.0733	$19,530
5% Renewable (Biomass/Small Hydroelectric)	5.00	$3,098,000	$13,020	0.42%	$0.0714	$2,603
5% REC Purchase	5.00	$3,183,000	$97,640	3.17%	$0.0733	$19,530
10% Electricity Use Reduction	0.00	$2,776,000	-$308,500	-10.00%	$0.0711	$0.00

Table 2: Environmental Benefits

	CO_2 Reductions Per $1,000 (Metric Tons)	SO_X Reductions Per $1,000 (Metric Tons)	NO_X Reductions Per $1,000 (Metric Tons)	CO_2 Reduction as % of Total Emissions
Dartmouth's Purchased Electricity (minus fees)	0.00	0.000	0.000	N/A
100% Renewable Estimate (Constellation)	14.6	0.142	0.037	15.8
50% Renewable Estimate (Constellation)	21.2	0.206	0.054	9.85
10 Year Frontier Partnership (Constellation)	36.7	0.358	0.094	20.3
5% Renewable (New Wind)	7.28	0.071	0.019	1.02
5% Renewable (Biomass/Small Hydroelectric)	54.6	0.532	0.139	1.02
5% REC Purchase	7.28	0.071	0.019	1.02

There are several options that Dartmouth College could pursuer in order to secure a renewable electricity portfolio. We recommend that Dartmouth make a written commitment to purchase renewable electricity to the level most economically feasible. We also recommend that, by June 24, 2004 (the first day of summer term), Dartmouth begin negotiations to arrange a contract with an electricity supplier that calls for a specific percentage of purchased electricity to be generated by renewable sources. Our specific recommendations vary depending on Dartmouth's level of commitment:

Strong Commitment

- Dartmouth enters into the Frontier Partnership with Constellation NewEnergy to purchase 100% of electricity from renewable sources.

Moderate Commitment

- Dartmouth makes the switch to five percent renewable electricity.

- We recommend that the five percent come from biomass and small hydroelectric sources because this plan is more economically feasible and saves more CO_2 emissions savings than a new wind source.

Alternative Fuels

We examined and compared two alternative fuels, biodiesel and liquid petroleum gas, and assessed the potential costs and benefits of their adoption at Dartmouth. Due to financial and logistical ease of adoption we focused our research on biodiesel.

As an alternative fuel produced from waste animal fats, virgin plant oil or recycled cooking oils, biodiesel can be poured into a standard diesel engine, furnace or boiler with no engine modifications in pure concentration (B100) or as a blend (B20) with petroleum diesel. Biodiesel offers several significant benefits, including a 78% reduction in lifecycle emissions of CO_2 by B100 over traditional Number 2 heating oil. Lifecycle emissions of B20 and other blends of biodiesel are proportional to the percent content of biodiesel in the blend. Biodiesel also reduces emissions of Carbon Monoxide, sulfur oxides, and particulate matter. However, biodiesel has a few drawbacks, such as congealing in cold weather and creating the possibility of a warranty void with the fuel switch. These risks are minimized with the use of a blend like B20. There are other advantages and disadvantages to the use of biodiesel (see Chapters 17 to 19 for more information).

How Stuff Works, http://www.dosomething.org/biodiesel.htm

Currently, purchasing biodiesel is more feasible for Dartmouth than producing it. However, it is important to note that the cost-benefit results for biodiesel are not static, as several trends indicate that it is becoming increasingly cost competitive and favorable. For example, the recent trend of increasing diesel prices and the expected depreciation of biodiesel prices should further reduce the cost of biodiesel adoption. Dartmouth has the opportunity to play a key leadership role in raising the community awareness about biodiesel and helping to develop a regional biodiesel market.

For our assessment, we focused on two broad areas of current diesel use at Dartmouth. First, we looked at off-road diesel engines, which include FO&M's eleven tractors and mowers, the Dartmouth Skiway's diesel groomers, snowmaking equipment and diesel generator and Advance Transit buses. Second, we examined the heating systems at Dartmouth-owned properties that use Number 2 heating oil, which is identical to off-road diesel. Dartmouth owns over 300 such properties in addition to numerous emergency generators throughout the campus.

Alternative Fuel Recommendations

Based on our assessment, we recommend that Dartmouth consider biodiesel as an alternative fuel. Our specific recommendation varies depending on Dartmouth's level of commitment:

Small-Scale Test Run

- Dartmouth works with Advance Transit to convert one bus to biodiesel.

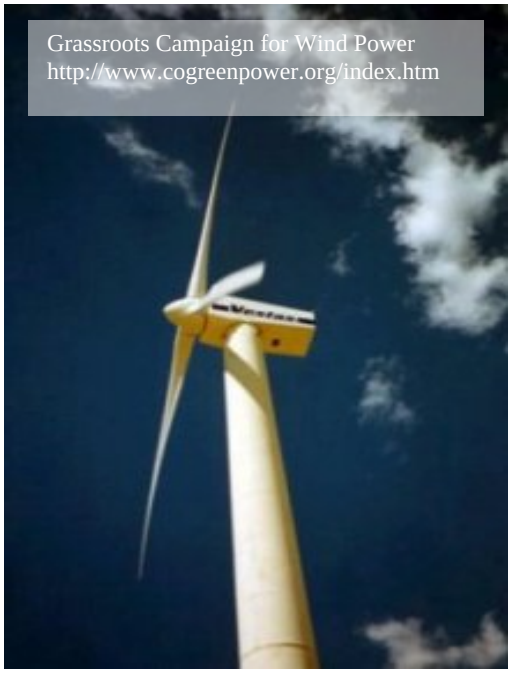
Medium-Sized Project

- Dartmouth adopts biodiesel for its tractors and mowers.

Large-Scale Commitment

- Dartmouth adopts biodiesel for its over 300 properties as well as all 25 Advance Transit buses.

Wind Energy



Wind turbines produce renewable energy with zero CO_2 emissions and could be used to produce a large proportion of Dartmouth's electricity needs in the future. Currently, wind is greatly underutilized in United States and especially in the Northeast. With the advent of new, more efficient wind turbine technologies, the cost of generating electricity from wind should continue to fall, making it more economically feasible to develop the resources in this area. Thus, we recommend that Dartmouth make an effort to support wind energy research and development in some way.

We assessed the feasibility of the placement of wind turbines at the Dartmouth Skiway and determined that a move to wind energy at the Dartmouth Skiway is not an option at this time. We found that development of wind energy is a promising area that has yet to gain the level of attention it deserves.

Thus, our recommendations are that:

- Dartmouth should asses the suitability of its land holdings for wind farms.

- Dartmouth should consider placing a small-scale wind turbine on one of its existing buildings or add turbines to its list of engineering projects.

Access the Spring 2004 Environmental Studies 50 Report: Reducing Fossil Carbon Emissions and Building Environmental Awareness at Dartmouth College at:

http://www.dartmouth.edu/~envs/

Or order a copy of this report by contacting the Environmental Studies Program at:

The Environmental Studies Program
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If you read just one thing: Global climate change is taking place and it is an issue of global concern. Our current social paradigm relies on fossil fuels and Dartmouth College is no exception. As a leader in liberal arts education, Dartmouth has a responsibility to assume a role in challenging this paradigm. By doing so, the college will be a leader in environmental awareness and responsibility. Reduction of fossil carbon emissions is an important first step in demonstrating environmental awareness and responsibility. At a personal level, we must each realize that the choices we make impact the environment and it is our obligation to reduce our impact on the environment.

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