Biodiesel: Fuel for Thought, Fuel for Connecticut's Future

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Significant Findings

The attached study by the Connecticut Center for Economic Analysis at the University of Connecticut reveals:

- ✓ By switching to biodiesel for home heating and in on-road and off-road heavy duty vehicles, Connecticut saves at least $20 million in averted health care costs; these savings increase as the price difference between biodiesel and conventional diesel narrows;
- ✓ Connecticut can preserve green space and put idle farmland to productive use to build its heating oil reserve with biodiesel;
- ✓ Connecticut can use biodiesel mixed with the newly mandated low-sulfur petro fuels to increase lubricity and cleanliness in diesel engines;
- ✓ Connecticut's neighbors (particularly Rhode Island) use biodiesel in school buses and school heating systems to reduce (cancer-causing and respiratory illness-causing) pollutants where children are present;
- ✓ The University of Connecticut uses recycled cooking oil to power a shuttle bus;
- ✓ Biodiesel has physical and chemical properties that make it desirable for use in transportation, home heating and power generation (low toxicity, highly decomposable, high flash point, high lubricity and low pollution (for example, no sulfur dioxide that leads to acid rain and almost half as much particulate matter); and,
- ✓ Biodiesel is four times more efficient than diesel fuel in utilizing fossil energy, that is, it releases more energy than it consumes in its production relative to conventional diesel that requires more energy to produce than it yields.

Executive Summary

Biodiesel is a fuel made from mixing vegetable oil and alcohol in the presence of a catalyst. The fuel resulting from the chemical reaction is a good substitute for conventional diesel fuel. Byproducts of its production are biodiesel, fertilizer, glycerine, and recovered alcohol. Nothing is wasted. Significantly, biodiesel burns in conventional diesel engines with no modification and reduces pollution (100% less sulfur dioxide, 37% less unburned hydrocarbons, 46% less carbon monoxide, and 84% less particulate matter[1]). Biodiesel has greater lubricity than conventional diesel fuel, resulting in smoother operation especially as new EPA requirements for low sulfur petro-(that is, conventional) diesel fuel will increase the lubricity in diesel fuel. Moreover, biodiesel is produced domestically from a variety of seed oils including soybeans, rapeseed, and corn. Ethyl alcohol (ethanol) is produced from corn (currently added to gasoline) and methanol is produced from biomass decomposition. Thus, idle farmland—such as that in Connecticut—could produce part of our fuel needs, thus reducing our dependence on imported oil. Imagine if we could produce 20% of our oil needs domestically and not need Middle Eastern oil. There would be fewer oil spills and reduced need for pipelines through politically and ecologically sensitive areas.

Burning biodiesel reduces pollution and carbon output. This is because burning ancient fossil fuel adds carbon to the atmosphere upsetting the carbon balance, while growing part of our fuel consumes carbon in the growing process and then releases it in combustion. The total *fossil* energy efficiency ratio (i.e., total fuel energy/total fossil energy used in production, manufacture, transportation, and distribution) for diesel fuel and biodiesel shows that *biodiesel is four times as efficient as diesel fuel in utilizing fossil energy* – 3.215 for biodiesel vs. 0.8337 for diesel. That is, as a study[2] notes, "In terms of effective use of fossil energy resources, biodiesel yields around 3.2 units of fuel product for every unit of fossil energy consumed in the lifecycle. By contrast, petroleum diesel's life cycle yields only 0.83 units of fuel product per unit of fossil energy consumed. Such measures confirm the 'renewable' nature of biodiesel." The report notes, "On the basis

[1] National Biodiesel Board, Lifecycle Summary, http://www.biodiesel.org/pdf_files/LifeCycle_Summary.PDF

[2] Biodiesel Lifecycle Inventory Study, U.S. Department of Energy and U.S. Department of Agriculture, May 1998.

of fossil energy inputs, biodiesel enhances the effective utilization of this finite energy source."

Biodiesel can be used in diesel engines (cars, trucks, busses, construction equipment), in jet engines, and, in heating and electricity generating systems. It blends easily with petro-diesel (a 20% blend is B20). Burning biodiesel in reciprocating engines produces less pollution across the board except for small increases in nitrogen oxides (this is an intermittent combustion process). In jet engines and in heating systems (continuous burn processes), use of biodiesel reduces nitrogen oxide emissions compared to fuel oil (a form of diesel fuel). This report estimates the net health benefits of using biodiesel in Connecticut's on- and off-road heavy-duty diesel vehicles and for heating oil.

With Connecticut ranking as the state 9th most susceptible to cancer risks associated with air quality, examining the public health effects of diesel exhaust becomes an issue of local importance.[3] Seventy-five thousand children and 202,800 adults in Connecticut suffer from asthma, and reports suggest that in one year smog is responsible for 2,500 hospital visits and 100,000 asthma attacks.[4] According to a study conducted in Los Angeles, ozone toxins are the known cause of between 10 and 20% (and up to 50% on bad days) of hospital admissions for respiratory illness.[5] The Union of Concerned Scientists has found that the total costs of environmental externalities of United States oil use to be between $54 billion and $232 billion in 1991, or $214 to $920 per capita, with human mortality and morbidity accounting for over 75% of the total environmental costs (as much as $182 billion annually).[6] The net benefit is the gross benefit less the cost, which is a function of the price per gallon difference between B20 and petro-diesel (the spread). The spread has recently been closing, making the net benefits larger for Connecticut.[7] CCEA's estimated net benefit to Connecticut of using biodiesel for home heating and in on-road and off-road heavy duty vehicles—given the costs as calculated

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[3] http://www.scorecard.org/env-releases/hap/rank-states.tcl. Also see, "Diesel and Health in America: The Lingering Threat," www.catf.us/goto/dieselhealth.

[4] "Connecticut's Air is Not Healthy," Clean Car Alliance and CT Environmental Fund, http://www.cfenv.org/PDFs/11-11-03%20Health%20Issues.pdf

[5] "Oil Slickers: How Petroleum Benefits at the Taxpayer's Expense," Institute for Local Self-Reliance, http://www.ilsr.org/carbo/costs/truecosttoc.html.

[6] "Subsidizing Big Oil," Union of Concerned Scientists, http://www.ucsusa.org/clean_vehicles/archive/page.cfm?pageID=817.

[7] Clean Cities Alternative Fuel Price Report, November 26, 2004.

by the predicted spread between B20 and distillate fuel prices and the averted health costs—as almost $20 million

Biodiesel is environmentally safer than petro-diesel. It is nontoxic (by comparison, table salt is ten times more toxic), produces less skin irritation than soap and water, it degrades four times as fast as petro-diesel (about as fast as sugar), and has a flash point significantly higher than that of petro-diesel, thus making it safer to store and handle. These characteristics imply that in the event of a spill or leak, compared to conventional diesel, biodiesel is less likely to explode or hurt humans, animals or fish.

Connecticut's neighbors use biodiesel in school buses and school heating systems. In February 2004, the EPA announced a $15,000 grant to the Rhode Island Department of Environmental Management (DEM).[8] With this grant, it will be possible for the DEM and the New England Asthma Regional Council (ARC) to prepare information packets about the risks that petro-diesel-powered school buses pose to children. This effort is part of the Clean, Green School Bus Awareness Program, whose purpose is to educate individuals about the severe risks petro-diesel exhaust poses. Since March 2003, the Warwick school district has been involved in a one-year pilot project in which the district school bus fleet uses a biodiesel/petro-diesel fuel mixture.

Warwick is the first city in the country to heat its schools with biodiesel fuel. Robert Cerio, Warwick Public Schools Energy Educator/Manager, proposed a three-year program to test a group of four schools using regular heating oil and blends of biodiesel fuel.[9] The program used various blends of biodiesel fuel in the boilers in three of the four schools, with the fourth used as a control. Cerio found that the B20 blend performed significantly better in terms of emissions and burning efficiency compared to the control school. In May 2003, phase two of the project began with the use of B20 fuel in boilers across the school district. If this project is successful, all thirteen Warwick school buildings will switch to B20.

Warwick found a way to make this initiative cost effective by investing in oil futures that alleviated the cost of using B20. This demonstrates that despite the higher cost of using B20, there are means available to reduce its cost and make widespread use

[8] EPA Press Release, "EPA Awards $15,000 to Rhode Island for Clean, Green School Bus Awareness Program," http://www.epa.gov/region1/pr/2004/feb/040207.html,
[9] www.rebuild.org/attachments/successstories/RhodeIslandBiodiesel.pdf.

economically feasible. The Warwick school system is implementing a curriculum that focuses on this cleaner burning alternative. The school system amended its curriculum with a portion based on a program created by the Northeast Sustainable Energy Association called Cars of Tomorrow and the American Community.[10] This should produce a new generation of citizens keenly aware of the benefits of cleaner, more efficient, renewable fuel.

The report details efforts and progress in other neighboring states in using biodiesel. In addition (and not reported herein), Boston Carbon Corporation is establishing the Certified Tradable Credits Process at the Massachusetts Department of Environmental Protection and for the ten-state Northeast Coalition, to be used as a model for all jurisdictions.[11] This will provide a market for buying and selling carbon credits worth $7 per ton so that operations that produce a lot of carbon can buy credits from those that do not. This is a benefit not included in our analysis.

There is much that Connecticut can do to promote biodiesel use. The University of Connecticut turned vegetable oil from its confectionaries into biodiesel for a test run of one of its shuttle busses.[12] Research continues. School districts could work with their counterparts in neighboring states to start biodiesel programs. And Connecticut could encourage its farmers to plant soybeans on land that is otherwise unproductive and encourage research into more productive oil producing plants. Increased biodiesel use is likely to occur at the local level as the benefits accrue at the local level. One use of Connecticut grown biodiesel could simply be to build a heating oil reserve to buffer its residents against supply shocks.

[10] "Back to School with Biodiesel," National Biodiesel Board, News release: October 6, 2003.
[11] http://www.bostoncarbon.com/home/index.html
[12] UConn Advance, "Out of the Frying Pan, into the Gas Tank," November 29, 2004.

Introduction

The twenty-first century introduced an era of increased global petroleum demand that has not been met with an increase in oil production. China's oil imports grew at an unprecedented 23% in 2003 and have driven worldwide demand up 2.9% to 81.1 million barrels daily, an increase in demand not seen since 1980.[13] Oil production facilities and refineries are operating near capacity around the world and are unable to keep pace with such rapid demand growth. World reserves are low and this tight supply situation creates a highly volatile market that reacts violently to shocks. Without reserves to buffer price shocks, the threat of terrorism is captured in increased risk premiums in the price of oil. Higher oil prices erode revenues by increasing costs throughout the economy because of the fossil fuel dependence of the U.S. economy.

The only way to insulate the economy from petroleum price shocks is to lower the dependence on petroleum in the economy. The most practical and least disruptive strategy to achieve this objective is to use alternative fuels. Biodiesel is a diesel fuel alternative produced from oilseeds, primarily soy, and can be grown and produced domestically. Biodiesel use is prevalent in Europe, where petroleum prices, and therefore incentive to use alternative fuels, are higher than in the United States.

Biodiesel is attractive as an alternative fuel source because its emissions profile is cleaner than that of diesel fuel. Biodiesel can be used in diesel engines without modification, and can be blended with petro-diesel fuel effectively. A blend of 20 % biodiesel and 80 % diesel fuel, called B20, is currently the most widely used form of biodiesel.

Connecticut stands to benefit from the use of biodiesel through improving air quality with the reduction of harmful vehicle (trucks, busses and construction equipment) emissions. These emissions are costly in that there is an apparently causal relationship between illnesses such as asthma and an increased the risk of life threatening diseases. The prominent use of heating oil in Connecticut homes is another use where biodiesel can reduce petroleum emissions and dependence. Many Connecticut farms have disappeared in recent years and could produce soy for biodiesel.

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[13] "Oil Demand Growth Seen at 24-year High." Reuters. http://msnbc.msn.com/id/5180521/

Energy Independence

All sectors of the United States economy stand to benefit by increasing biodiesel use. More widespread use of biodiesel has the potential to reduce our dependence on imported oil while simultaneously strengthening domestic agriculture. Because biodiesel and biodiesel blends work in existing diesel engines and burners (in homes, schools and power plants), the infrastructure and equipment-related costs of adjustment are minimal. As the U.S. uses biodiesel in larger quantities, economic gains will accrue because biodiesel production will achieve economies of scale reducing average (per unit) cost. Agricultural research will likely develop new hybrid oil-producing plants that thrive in poor soils with less water yielding larger quantities of vegetable oil. As biodiesel prices decline, vehicle manufacturers will have ample incentive to optimize diesel engine technology.

In 2003, the United States imported nearly $130 billion of energy related products, accounting for nearly 25% of the $490 billion trade deficit.[14] Unfortunately, as the trend towards increasing oil dependence continues, the Energy Information Association (EIA) predicts that U.S. oil imports will increase from 11.5 million bbl/day to 20.7 million bbl per day by 2025. The Department of Energy projects that this will lead to a trade deficit for imported crude oil and petroleum products of close to $200 billion.[15] Oil imports to the U.S. are increasing from all around the globe. According to the Energy Information Association's 2004 Outlook Report, net imports of petroleum, "which accounted for 54% of total U.S. petroleum demand in 2002—up from 37% in 1980 and 42% in 1990—are expected to account for 70% of total U.S. petroleum demand in 2025."[16] Reducing this number clearly becomes vital for assuring a strong and stable domestic economy. Moreover, the Department of Energy estimates that every $1 billion in trade deficit costs 27,000 American jobs.[17] Another Department of Energy study estimated that U.S. oil dependence has already cost the country $3.4 trillion from 1970 to

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[14] "Biomass Benefits: Economic Growth," Biomass Program, Department of Energy. http://www.eere.energy.gov/biomass/economic_growth.html

[15] "Annual Outlook 2004 with Projections to 2025," Energy Information Association. U.S. Department of Energy, http://www.eia.doe.gov/oiaf/aeo/economic.html.

[16] "Annual Energy Outlook 2004 with Projections to 2025," Energy Information Association, U.S. Department of Energy, http://www.eia.doe.gov/oiaf/aeo/economic.html.

[17] "Biomass Benefits: Economic Growth," Department of Energy. http://www.eere.energy.gov/biomass/economic_growth.html

1999. According to the report, "the present value of these losses is close to $7 trillion, almost an entire year's GDP…Clearly, oil dependence ranks among the most significant economic problems the United States has faced over the past thirty years."[18]

Following price-shocks in the early 1970's, President Ford mandated the creation of the Strategic Emergency Petroleum Reserve (SEPR) in 1975. The Reserve is currently prepared to supply the United States with 53 days of oil. However, maintaining such a reserve is expensive, as well as an issue of national security. The SEPR costs approximately $21 million per year to run; the Department of Energy budgeted $157 million for additional oil purchases for the Reserve in 2004.[19]

Of the 11.5 million bbl per day we import, 6.54 million of those barrels come from sources outside the Western Hemisphere, increasing transportation expenses, risking oil spills and their attendant environmental contamination that have direct and indirect economic costs. Furthermore, ensuring reliable delivery of this oil becomes increasingly difficult as well. Approximately 20% of U.S. oil imports originate in the Persian Gulf region, a highly volatile region that has captured much of our interest in the past few decades, much of that interest due to the abundance of Middle Eastern oil.

As a matter of local economic stability and competitiveness, developing biodiesel as an alternative fuel source in home heating systems also becomes a subject of interest. According to the EIA for the year 2000, 7.7 million homes in the United States consume No. 2 heating oil, of which 69%, or 5.3 million homes, are located in the Northeast corridor.[20] While national use of heating oil has decreased significantly from the 1970's, from about 20% of the population to well under 10%, the Northeast uses a large quantity of home heating oil (it is the largest component of oil consumption in Connecticut, excluding gasoline). In Connecticut, 682,000 heating oil customers consume 545,000

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[18] "Costs of Oil Dependence: A 2000 Update." Oak Ridge National Laboratory, Department of Energy, http://www.ornl.gov/~webworks/cpr/v823/rpt/107319.pdf, p 27.
[19] "Strategic Emergency Petroleum Reserve—Quick Facts." Office of Fossil Energy. U.S. Department of Energy. http://www.fe.doe.gov/programs/reserves/spr/spr-facts.shtml
[20] "Regional Energy Profile: New England," Energy Information Association, U.S. Department of Energy. http://www.eia.doe.gov/emeu/reps/abstracts/new_eng.html#consumption.

gallons of heating oil each year.[21] Half of Connecticut homeowners use heating oil to heat their homes.[22]

The potential for the use of biodiesel in home heating devices becomes particularly relevant following the oil price shocks in January and February 2000, when prices rose from $1.21 to $1.99, an increase of 65% per gallon. According to a report from the National Biodiesel Board, "The phone was ringing off the hook with government agencies wanting to know if they could use biodiesel as heating oil – even the White House called," said Krysta Harden, Washington representative for the American Soybean Association. Ms. Harden added, "Representatives on Capital Hill wanted to see how biodiesel could alleviate the heating oil shortage and how it could fit into the overall energy program long term."[23] Although some technical complications currently limit recommended biodiesel use in home heating systems to blends of less than 30% biodiesel, the use of such blends could help stabilize heating oil prices.[24] One study completed for the National Renewable Energy Laboratory (NREL) and the Department of Energy found that "one would recommend blends of 30% or less could replace fuel oil with no noticeable changes in performance...though it is recommended that a reasonably low level blend of 20% be used in field testing."[25] The Warwick school district in Rhode Island has thus far completed the most extensive testing involving the use of biodiesel in heating systems and has so far reported success. Without changes in fuel taxes, consumers using biodiesel will face slightly higher prices. However, expanded use of domestically grown and produced biodiesel products in all forms will better help stabilize home heating prices in the future, and expanded use would probably generate significant economies of scale, reducing or eliminating the cost differential in the future. Since the

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[21] "Heating Oil Statistics," Independent Connecticut Petroleum Association, http://www.icpa.org/statistics.htm.

[22] "Gas Most Popular Home Heating Fuel, Census Bureau Survey Shows." http://www.census.gov/Press-Release/www/releases/archives/american_community_survey_acs/003053.html

[23] "Biodiesel, Next Stop Home Heating Oil," National Biodiesel Board, http://www.biodiesel.org/markets/hom/default.asp.

[24] Testing has shown that copper and natural rubber parts need to be replaced with steel and synthetic rubber parts for long-term reliable use. See the section, Technical Concerns for Biodiesel, for more information.

[25] Krishna, C.R. "Biodiesel Blends in Space Heating Equipment," National Renewable Energy Laboratory. U.S. Department of Energy, http://www.biodiesel.org/resources/reportsdatabase/reports/hom/20011201_htg-001_spaceheating.pdf. pp 11, 12.

price spike of 2000, a Northeast Heating Oil Reserve has been created, with reserves held in Connecticut, New Jersey, and Rhode Island. Biodiesel is a long term alternative to reduce demand for the petroleum content of home heating oil, especially in the Northeast, and thus the cost of special initiatives like the Reserve.[26]

With world and domestic oil reserves running down and controversy over the drilling in previously protected lands in Alaska and elsewhere in the pursuit of oil, turning to an alternative fuel source that can be produced domestically offers a compelling alternative. Many farmers and public officials see the expansion of domestic agricultural and refining markets as a result of increased biodiesel use as a boon to the United States economy.

History

The use of vegetable oils as fuel sources is as old as the diesel engine itself. Dr. Rudolph Diesel, inventor of the diesel engine, captured energy from a variety of fuels, including several vegetable oils, throughout the 1890's. At the World's Fair in 1900, Diesel demonstrated the use of his high efficiency engine using peanut oil, ultimately taking home the Grand Prix, the Fair's highest honor. Revolutionary in his vision of energy, Diesel predicted in 1912 "the use of vegetable oils for engine fuels may seem insignificant today, but such oils may become in the course of time as important as the petroleum and coal tar products of our time."[27] However, despite Rudolph Diesel's optimism, the use of biodiesel as a viable petroleum alternative has repeatedly been overlooked.

With abundant sources of both coal and oil available in the early 1900s, biodiesel fuel was simply not cost competitive. As large reserves of oil were discovered both domestically and abroad in the 1920's, automobile manufacturers turned to oil as the main source of transportation fuel. Gasoline-powered vehicles, adopted by Henry Ford for his Model T, soon began to dominate the automobile market, as consumers complained of the diesel engine's noisiness and particulate emissions, as well as its

[26] "Northeast Heating Oil Reserve," Energy Information Association, http://www.eia.doe.gov/oil_gas/petroleum/special/nehor/nehor.html.
[27] "National Biodiesel Day, May 18th: Rudolph Christian Carl Diesel," National Biodiesel Board. http://www.biodiesel.org/biodiesel_day/bio.shtm.

heaviness and poor cold-start capabilities. Demand for cars quickly escalated following post World War II suburbanization efforts, and sales of gasoline-powered vehicles soared. Additionally, the spread of electricity beginning in the early 1900s further popularized the use of coal and oil, as both fuels remained abundant and cheap. Only during the oil crises of the 1970's did the United States begin to seriously consider researching alternate, and hopefully renewable, sources of energy, though the return of low oil prices in mid 1980's again slowed public desire to see such research continue. With the establishment of the National Biodiesel Board in 1992 and the creation of several biodiesel production and distribution plants around the U.S., awareness is beginning to grow, further strengthening the market for product. Strong environmental advances have also made the use of alternative fuel sources more prevalent through the 1990's that continue today. Smaller, more localized movements have led to the institution of biodiesel buses for some university and public school systems nationwide. Universities including Harvard, Indiana, California, and Colorado, run bus services on biodiesel blends in an effort to conserve fossil fuel energy and create a healthier environment on campus. A number of national parks and federal fleets have converted to biodiesel, and the Navy, Air Force, U.S. Postal Service, and NASA utilize vegetable oil-based fuels as well. Most striking, however, is the number of individuals who have taken to creating biodiesel blends at home, obtaining and processing waste oil from Chinese and fast food restaurants, for use in cars, off-road diesel vehicles, and home heating systems.

Biodiesel Production

There are currently conversion kits available to diesel engine owners that allow the use of waste vegetable oil (WVO) as a fuel source, and it is important to distinguish between WVO and biodiesel. Vegetable oils and animal fats consist of long chains of triglycerides that must be broken down in a process known as transesterification in order to become biodiesel.

Biodiesel derives from vegetable oil by a process of transesterification. Alcohol, usually methanol, is added to the vegetable oil, and using sodium or potassium hydroxide as a catalyst, the glycerin and methyl esters are separated. The glycerin is then removed to be sold and biodiesel remains. This process is economical and straightforward because it occurs at low temperature (150° F) and low pressure (20 psi).

Once the oil, methanol and catalyst are mixed, the entire transesterification process takes 3-6 minutes. In this chemical reaction, methanol substitutes for the glycerin in a chemical reaction, generally using lye as a catalyst. The final part of the process is separation of the less dense esters floating above the denser glycerol. The floating esters are usually drawn out of the primary vessel and the process is repeated, with less methanol and catalyst used in the secondary transesterification. This ensures the greatest yield of esters.

Once the transesterification process is complete, glycerol must be separated from the ester product and methanol must be evaporated for reuse. The biodiesel ester is then washed with acidified water in order to remove the glycerol and methanol. At this point, biodiesel meets the standard set by the American Society of Testing and Materials (ASTM) specification D 6751. This standard is the minimum accepted values of the properties of the fuel to provide satisfaction and safety to users. After vegetable oil has undergone transesterification, it has become biodiesel and can then be readily utilized in existing diesel engines without any modifications.

Straight vegetable oil used as a fuel does not meet the ASTM specification and requires the purchase of a conversion kit that typically ranges in price from $500 to $800 before it can be run in a diesel engine. Vegetable oil is much thicker than conventional diesel and biodiesel blend fuel and must be heated, and thus thinned, so the fuel injectors can properly atomize it. A conversion kit supplies the car with an additional tank for vegetable oil and works to heat the vegetable oil while the car is running on regular diesel fuel (or biodiesel, which has similar fuel performance and combustion properties as regular diesel). Using diesel or biodiesel when starting and stopping works to flush the system of waxy build-up that may occur. Once the car has been started and the vegetable oil has been properly heated, the driver flips a switch to initiate vegetable oil use.

If the vegetable oil fuel is not properly atomized, it will not burn properly, forming deposits on the injectors and in the cylinder head, leading to poor performance, higher emissions, and reduced engine life. As such, drivers following this straight vegetable oil method must carefully monitor fuel systems and injection pumps for clogging that occurs particularly in cold weather. Straight vegetable oils must be de-acidified to prevent engine malfunction. If using waste vegetable oil (WVO), one must also filter and dewater the oil before using to keep engines running smoothly.[28] Thus, there are significant disadvantages and uncertainties involved in using straight vegetable oil, though future technologies may emerge that overcome these drawbacks. Because of the ease with which biodiesel works with existing technologies, it provides the advantages of decreased emissions without the drawbacks involved in using WVO in a diesel engine.

A wide variety of oilseeds can be use to produce biodiesel. In the United States, soybean oil yields most biodiesel, whereas in Europe rapeseed (canola) oil yields most biodiesel. Whatever the type of oilseed used, the chemical composition of the oil determines biodiesel quality. Goering, et al. (1981) studied the characteristic properties of eleven vegetable oils to determine which oils would be best suited for use as an alternative fuel source and found that corn, rapeseed, sesame, cottonseed, and soybean oils had the most favorable fuel properties.[29]

Vegetable oils with low free fatty acid levels are best suited for biodiesel. Catalysts are used to free the esters from the fatty acids, and when free fatty acids are present in the vegetable oil, they consume catalyst without providing and energy in the form of esters. Oils can be neutralized, reducing the free fatty acids to less than 0.5% of the oil, at which catalyst consumption is acceptable. High phosphorous content in biodiesel is also problematic because it leads to emulsification of natural rubbers, which can cause gasket failure. Phosphorous in safe in levels below 3 to 4 ppm is hazardous to use because the risk of emulsification is too high. Insolubles in the fuel will not filter out in the transesterification process, ending up in the final fuel, so no more than 0.8% of the oil may be insoluble.

The methanol used in the transesterification process is flammable and toxic, and great caution must be used in its handling. Biodiesel is more viscous than regular diesel fuel because as vegetable oils cool, wax crystals form and the oil clouds and begins to

[28] "Straight Vegetable Oil as a Diesel Fuel," Journey to Forever. http://www.journeytoforever.org/biodiesel_svo.html.
[29] "Fuel Properties of Eleven Vegetable Oils." http://www.biodiesel.org/resources/reportsdatabase/reports/gen/19820101_gen-169.pdf

solidify. Soy oil solidifies at –16° C. Biodiesel made with ethanol usually has a lower clouding point than biodiesel made with methanol, but ethanol is prohibitively more expensive.

There are three commonly used caustic catalysts in the transesterification process: potassium hydroxide (KOH) crystals, sodium hydroxide (NaOH) crystals, both dissolved in methanol, and sodium methylate. Sodium methylate is the most easily used because it exists in liquid form at room temperature. Sodium methylate is also the most effective catalyst of all three, and produces low final salt contents, which promotes higher quality glycerin.

Benefits of Biodiesel

Though historically discounted due to its higher market price, biodiesel remains competitive with, if not superior to, petro-diesel fuel in terms of providing efficient fuel performance, satisfying environmental and public health concerns, offering domestic economic opportunity, and addressing issues of national security.

Currently recognized by both the U.S. Departments of Energy and Transportation, biodiesel is designated an alternative fuel. Additionally, in December 2001, the American Society of Testing and Materials (ASTM) officially approved Specification (D 6751) for biodiesel fuel, a move that has been seen as crucial in standardizing and regulating the production and consumption of biodiesel fuel. Since that time, the National Biodiesel Board has organized the National Biodiesel Accreditation Commission to assist in enforcing fuel quality standards by auditing biodiesel producers and marketers to ensure a reliable and consistent product.[30] Assuring biodiesel quality through standardization and regulation assures consistent and reliable performance for all.

Diesel engines, designed to run on a variety of vegetable oils, as well as regular diesel oil, perform remarkably well with both biodiesel blends (BXX, where XX≤100) and pure biodiesel (B100). One of the most important features of biodiesel is its ability to perform in a conventional diesel engine without any alterations, keeping equipment

[30] "Biodiesel Benefits," National Biodiesel Board, http://www.biodiesel.org/pdf_files/Benefits%20of%20Biodiesel.Pdf

modifications and infrastructure adjustment costs minimal. Both regular diesel #2 and biodiesel share similar fuel economies. According to the National Biodiesel Board, "in over 15 million miles of in-field demonstrations biodiesel showed similar fuel consumption, horsepower, torque, and haulage rates as conventional diesel fuel."[31]

Additionally, biodiesel maintains a higher energy density than any other competing alternative fuel source, as the chart below shows. This higher energy density translates into a lower weight for onboard fuel systems than with other alternative fuel sources, "easing packaging concerns and allowing the payload capacity of the original vehicle to be maintained."[32]

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[31] "Biodiesel Performance," National Biodiesel Board, http://www.biodiesel.org/pdf_files/Performance.PDF. [According to one EPA study; a 20% blend of biodiesel (B20) can lead to a 1-2% decrease in fuel economy. "A Comparative Analysis of Biodiesel Impacts on Exhaust Emissions," U.S. Environmental Protection Agency, http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20021001_gen-323.pdf, pp iii.]

[32] "Market Potential for Biodiesel in Regulated Fleets, Marine Vessels, and Underground Mining Equipment," Booz-Allen&Hamilton Inc, http://www.biodiesel.org/resources/reportsdatabase/reports/gen/19981111_gen-207.pdf. pp III-18,19.

Table 1: Fuel Energy Content by Volume[33]

	Diesel	B20 biodiesel blend	Compressed Natural Gas	Liquefied Natural Gas	Liquefied Petroleum Gas	B100
Net Energy Content per Unit Volume in BTU's	128,700/gal	124,839/gal	37,830/gal	75,820/gal	83,5000/gal	118,170/gal
Energy Content per Unit Volume Relative to Diesel	1.00	.97	.30	.59	.65	.918
Volume Needed to Equal One Gallon of Diesel	1.0 gal	1.03 gal	3.4 gal	1.7 gal	1.6 gal	1.089 gal

Since the specification approval of biodiesel in December 2001, a number of companies that rely on petro-diesel have recognized biodiesel as a reliable fuel source alternative. The John Deere Company, which specializes in manufacturing diesel-powered tractors and mowers, approved the use of 5% biodiesel under warranty shortly after the ASTM approval announcement. In fact, Ted Breidenbach, Manager of Worldwide Engine Engineering for John Deere Power Systems, commented at the time his approval that "the quality of biodiesel as a fuel source has improved tremendously in recent years…. We're confident that when it's used per factory specifications it will generate the performance producers have come to expect from their John Deere equipment."[34] Companies including Cummins and Caterpillar have similar

[33] "Market Potential for Biodiesel in Regulated Fleets, Marine Vessels, and Underground Mining Equipment," Booz-Allen&Hamilton Inc, http://www.biodiesel.org/resources/reportsdatabase/reports/gen/19981111_gen-207.pdf, pp III-18
[34] "John Deere Approves Use of Eco-Friendly Biodiesel Fuel for It's Products," John Deere Company. http://www.deere.com/en_US/newsroom/2002/releases/corporate/020221_biodiesel.html.

recommendations concerning biodiesel and biodiesel blends.[35] The use of biodiesel in off-road diesel equipment becomes an increasingly attractive alternative citing the May 2004 passage of the Clean Air Non-road Diesel Rule.[36]

Biodiesel also offers a higher level of lubricity to fuels (blends), reducing friction and engine wear. In fact, a one percent blend of biodiesel can increase lubricity by up to 65%.[37] As biodiesel is already recognized as a fuel and fuel additive by the EPA, its use as an additive for its ability to better lubricate engines could be potentially useful in the future, with the federally required adoption of ultra-low sulfur fuel under the Clean Truck and Bus rule we discuss below.

Biodiesel carries a higher cetane rating than conventional diesel fuel. The cetane rating measures a fuel's combustion quality, and is determined by the ignition delay period. Higher numbers have been associated with reduced engine roughness and with lower starting temperatures for engines. Regular diesel has a cetane number from 40 to 46, and premium diesel between 45 and 50. A blend of 20% biodiesel, B20, can raise the cetane level of regular diesel 3 points, which would put the blend at premium fuel quality.[38] Premium fuels also command a higher price, and so advertising biodiesel as a premium fuel could make blends more price competitive, as well as potentially increase consumer confidence.

Biodiesel sustains a much higher flashpoint than regular (petro) diesel fuel, requiring a higher temperature for combustion. Pure biodiesel (B100) has a flash point of 300°F, while petro-diesel has a flashpoint of 140°F. The greater the percentage of biodiesel used in a blend, the higher its flash point. As such, biodiesel and biodiesel blends reduce the risk of explosion during an accident and thus become especially appealing options for trucks and buses carrying particularly precious cargo, including passenger and school buses.

Due to its renewable nature, biodiesel has a positive energy balance, unlike petro-diesel. According to one study from the National Renewable Energy Laboratory,

[35] "Standards and Warranties," National Biodiesel Board, http://www.biodiesel.org/resources/fuelfactsheets/standards_and_warranties.shtm.
[36] More detailed information concerning the new rule can be found in the Federal Legislation Section.
[37] "Biodiesel Performance," National Biodiesel Board, http://www.biodiesel.org/pdf_files/Performance.PDF.
[38] "Biodiesel Facts," Journey to Forever. http://journeytoforever.org/biodiesel.

"biodiesel yields 3.2 units of product energy for every unit of fossil fuel energy consumed in its life cycle. The production of B20 yields .98 units of fuel product energy for every unit of fossil fuel consumed. By contrast, petroleum diesel's life cycle only yields .83 units of fuel product energy per unit of fossil fuel consumed."[39] By creating more energy than it consumes, biodiesel is a net contributor to our energy needs, instead of a net detractor, as are fossil fuels.

Environmental Impact

Biodiesel, originating from plant and animal sources, is 100% biodegradable and 100% renewable, making it an environmentally appealing option for many who oppose our reliance on dwindling fossil fuel supplies. According to the National Biodiesel Board, "tests sponsored by the Department of Agriculture confirm that biodiesel is ten times less toxic than salt and biodegrades as fast as dextrose (a test sugar)."[40] As such, issues surrounding fuel transportation and associated leaks, crashes, and spills, become less of a safety hazard, making biodiesel an especially appealing option for conservation areas and vulnerable marine environments.

Yellowstone National Park served as the pilot project in 1995 for a "Greening the National Parks" initiative by advocating the use of biodiesel, supported by the National Park Service. Yellowstone, along with 22 other national parks around the country, is now utilizing pure biodiesel or biodiesel blends in a majority of its construction and maintenance equipment.[41] Channel Islands National Park has been using B100 in its diesel boats and according to Kent Bullard, maintenance supervisor, "We are an environmental organization, and we should be willing to be in the forefront in demonstrating things that have a positive environmental impact," adding, "We haven't had any performance issues; the biodiesel is performing just as well as diesel."[42]

It is the fuel's low emissions levels that make it particularly appealing to many environmental and public health officials involved in clean air policy. In 2000, biodiesel

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[39] "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus," National Renewable Energy Laboratory http://www.nrel.gov/docs/legosti/fy98/24089.pdf.
[40] "Environmental Benefits," National Biodiesel Board, http://www.biodiesel.org/pdf_files/Enviro_Benefits.PDF.
[41] "Greening the National Park Service: Biodiesel in the National Parks," National Park Service. U.S. Department of Interior, http://www.nps.gov/renew/npsbiodiesel.htm
[42] "Channel Islands National Park," http://www.biodiesel.org/resources/users/stories/channelisle.shtm

become the only alternative fuel in the country to pass the rigorous Tier I and Tier II health effects testing required by the Environmental Protection Agency under the Clean Air Act for the official registration of fuels and fuel additives. These health effect tests, required as of June 1994, are arranged in a three-tier system. As outlined by the EPA registration regulations, “Tier I testing requires analysis of the combustion and evaporative emissions of Fuel or Fuel Additives and a survey of existing scientific information on the public health and welfare effects of these emissions. Tier II testing requires manufacturers to conduct specified toxicology tests to screen for potential adverse health effects of the F/FA emissions. Additional testing may be required under Tier 3 at EPA’s discretion.”[43] In passing these tests, biodiesel has proven itself a safe fuel.

In October 2002, the EPA also released a comprehensive comparative analysis of biodiesel emissions, examining the effects of biodiesel on exhaust emissions. The investigation found that emissions varied depending on the fuel’s origin (soybean, rapeseed, animal fats); Table 2A reports the overall findings.

Table 2A: Average Biodiesel Intermittent Combustion Emissions Compared to Petro-Diesel According to EPA[44]

Emission Type	Pure Biodiesel (B100)	B20 blend
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
Nitrogen Oxides	+10%	+2%
Sulfates	-100%	-20%*

* Based on a B100 result

Each pollutant ranks among the Environmental Protection Agency’s top criteria for measuring overall air quality. Emission of unburned hydrocarbons, a contributing factor to the formation of fog, is significantly reduced with biodiesel (and blends) use, as well as particulate matter and carbon monoxide emissions , both of which are toxic and

[43] “Registration of Fuels and Fuel Additives: Changes in Requirements,” Environmental Protection Agency, http://www.epa.gov/fedrgstr/EPA-AIR/1997/March/Day-17/a6023.htm.
[44] “Biodiesel Emissions,” National Biodiesel Board. http://www.biodiesel.org/pdf_files/emissions.PDF.

deemed detrimental to human health. Sulfur emissions, which contribute to acid rain and are toxic in their own right, are absent in biodiesel emissions. Results concerning biodiesel nitrogen oxide (NOx) emissions vary from study to study, and while the EPA report found nitrogen oxide emissions actually increase with biodiesel combustion, there are currently several studies and projects focused on reducing these emissions' levels to be comparable or well below the emissions found in conventional diesel fuel.

Biodiesel does not disrupt the natural carbon cycle of the biosphere, as fossil fuels do. Originating from contemporaneous plant sources, biodiesel effectively takes in as much carbon dioxide as it ultimately releases upon burning, while fossil fuels, trapped deep in the ground for millions of years, increase the net carbon total in the atmosphere when extracted and burned. This increase in carbon dioxide in the atmosphere is linked to global warming. The carbon dioxide, when emitted from fossil fuels, travels up to the highest layers of the atmosphere where it traps reflected sunlight from escaping the planet, inevitability leading, (some think), to global climate change. The real benefits of using biodiesel are in the long term, and measured not only at the tailpipe, but also through an analysis of the life cycle of the fuel.

The National Renewable Energy Laboratory (NREL) conducted a study comparing life cycle emissions of soy-based biodiesel use in an urban bus. In focusing on the life cycle, rather than solely the tailpipe emissions, a better picture of the overall effect on air quality is shown. Over the life cycle of biodiesel, the majority of emissions are found in the use of fertilizer to grow the oilseeds and in processing the soy to harvest the oil. This processing step uses electricity; the analysis assumed that fossil fuels are burned to provide this electricity. If biodiesel were used in power generation, then emissions would be further reduced. The NREL study concluded that B100 reduced net life cycle carbon emissions 8.03% and B20 1.61%. Particulate matter emissions, evaluated over the life cycle of B100, declined 32.41%, and in tailpipe emissions by 68%.

Biodiesel hydrocarbon emissions are reduced at the tailpipe by 35 %, yet total life cycle hydrocarbon emissions were found to increase by 35 %, due mainly to the emissions accrued in the soybean crushing process, where it is assumed fossil fuels are used. Nitrogen oxide emissions were found to increase by 13% and 2.67% for B100 and B20, respectively. Altering the timing of a diesel engine can reduce nitrogen oxide emissions, yet sometimes increases particulate matter (PM) emissions. There are also emission filters available that can absorb both NOx and PM emissions. In one study, it was even found that PM accumulation and oxidation in the filter was increased with the addition of a NOx absorber.[45]

Biodiesel Limitations

One of the most significant factors limiting widespread use of biodiesel is certainly the fuel's relatively high price compared to conventional diesel fuel, assuming both bear the same fuel tax. Currently, pure biodiesel (B100) prices are between $2.75-$4/gal. The premium above regular diesel for B20 blended diesel is $.34-$.70/gal.[46] However, when taking into account the environmental and public health benefits that can potentially arise from the transition to biodiesel, the use of such an alternative fuel becomes more appealing. One study by the University of Georgia indicates that fleets using a B35 blend would incur lower energy costs than fleets converting to other sources of alternative fuels, due to biodiesel's low conversion costs. According to the study, "Assuming a 35% blend, biodiesel can comply with regulatory emissions standards; biodiesel fuels at prices as high as $3.00 per gallon are competitive with other alternative fuels. This competitiveness is underscored by the low infrastructure cost and lack of engine/fuel system cost of biodiesel," relative to other alternative fuels.[47]

Lack of Local Suppliers

Until biodiesel use becomes more widespread, difficulties in marketing the fuel continue. Economies of scale are the vehicle by which a firm or industry lowers the unit price of the product; until that point, biodiesel sales will remain limited. Currently, World Energy, the United States' largest distributor of biodiesel, holding about 75% of the market, adds a $90 shipping fee to each 55-gallon shipment, which means adding $1.63 per gallon additional charge. In contrast, a 3,000-gallon tanker shipment adds only

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[45]" Diesel NOx adsorber aids particle filter clean-up." http://www.findarticles.com/p/articles/mi_m0CYH/is_7_7/ai_100606342

[46] "Market Potential for Biodiesel in Regulated Fleets, Marine Vessels, and Underground Mining Equipment," Booz-Allen & Hamilton, http://www.biodiesel.org/resources/reportsdatabase/reports/gen/19981111_gen-207.pdf, pp II-4.

[47] "A Comparative Analysis of Biodiesel, Compressed Natural Gas, Methanol, and Diesel," University of Georgia, http://www.biodiesel.org/resources/reportsdatabase/reports/tra/19940101_tra-030.pdf. pp 15.

a shipping cost of $1.10 per gallon,but many individuals and businesses are not equipped to make such large purchases. Greater demand for biodiesel would soon enable distributors to expand their capacity, reducing shipping costs and allowing for smaller deliveries. With a greater number of biodiesel distribution centers, the purchase of fuel would also become more convenient for the consumer.

Currently in the Northeast, there are two B20 pumps, located in New Haven and Portland, Connecticut available only to specialized commercial vehicles. Public pumps are available to consumers in Boston and Holyoke, Massachusetts. However, neither of these options is convenient for those seeking out biodiesel in Connecticut. One biodiesel co-op does exist in Southington, Connecticut. Its supplier is World Energy, and the co-op sets a fee of $2.75 per gallon for pure biodiesel (B100), plus an added delivery charge, depending on location. The minimum purchase requirement is still 30 gallons, still a sizable order, though it remains smaller than buying directly from World Energy. The co-op currently delivers on an "as-needed" basis, although the ultimate goal of establishing a public pump in Connecticut to meet increased demand remains on the horizon.

Using Incentives

Until the true environmental and public health risks involved with the continued use of petro-diesel are accounted for in the cost of the fuel, it seems petroleum will continue to dominate the market. However, as experience on both the federal and state levels has proved, tax incentives that aid alternative fuels to become more price competitive can be successful.

Connecticut currently funds a Corporation Business Tax credit (to expire January 2008), which is available for 50% of expenditures on equipment and construction relating to compressed natural gas (CNG), liquefied natural gas (LNG), or liquefied petroleum gas (LPG) refueling stations, as well as electric vehicle recharging stations. The credit also extends to the purchase and installation of equipment used in dedicated or duel fuel CNG, LNG, LPG, or electric vehicle conversions. A 10% Corporation Business Tax credit is also available for 10% of the incremental cost of a new dedicated CNG, LNG, LPG, or electric vehicle, to be carried forward for up to three years. The state exempts from sales tax purchases of hybrid electric vehicles (HEV's) with a fuel economy rating of at least 40 miles per gallon (mpg) and the original purchase of dedicated natural gas, LPG, hydrogen, or electric vehicle.[48] The inclusion of biodiesel within the available tax credits, or the creation of new, independent tax incentives for biodiesel, would go a long way in affirming the use of this sustainable and environmentally friendly fuel source.

Technical Concerns for Biodiesel

While biodiesel does have the remarkable capacity of being utilized directly in existing diesel engines, a few drawbacks remain. Biodiesel, because it contains phosphorous, acts as a solvent on some system components, such as natural rubber gaskets and hoses, breaking them down over time. Most cars sold in the mid-1990s or later do not use any rubber parts, so this concern diminishes as gasket quality and composition improves. While this is a concern, many older model cars have also been used with no degradation of engine parts.[49]

The replacement of small rubber parts is a relatively low cost option, compared with costs of purchasing competing alternative fuel vehicles. Similar concerns facing non-metallic parts in home heating systems exist as well, although some manufacturers interested in producing biodiesel-compatible systems have suggested replacing these parts with more durable materials: natural rubber parts with synthetic rubber, and copper tubing with steel. The General Services Administration also recommends using blends no higher than B20 in home heating systems at this time.[50]

When implementing biodiesel in engines that have previously run on petroleum-based diesel, fuel filter clogging may occur. Because of its solvency characteristics, biodiesel often breaks down and cleans out deposits left by petro-diesel fuel, ultimately leaving them in the fuel filter. Checking and replacing fuel filters, especially during the

[48] "State Incentives and Laws: Connecticut," Energy Efficiency and Renewable Energy Program. Department of Energy, http://www.eere.energy.gov/cleancities/vbg/progs/laws2.cgi.
[49] "Biodiesel and Your Vehicle," Journey to Forever. http://journeytoforever.org/biodiesel_vehicle.html
[50] "Biodiesel Blends in Space Heating Equipment," National Renewable Energy Laboratory. http://www.biodiesel.org/resources/reportsdatabase/reports/hom/20011201_htg-001_spaceheating.pdf. pp 9, 12.

first few weeks of running on biodiesel, is recommended to avoid fuel filter clogs and ensure long engine life.[51]

As with all diesel fuels, biodiesel has some problematic cold flow properties. Whereas conventional diesel begins to gel at around 15°F, pure soybean-based biodiesel (B100) tends to gel at around 32°F, while biodiesel from waste oil and grease made up of animal fats can begin to form wax crystals at as high a temperature as 68°F.[52] While these findings illustrate that special handling and care are necessary during winter months, evidence has shown that the inclusion of certain additives can greatly improve biodiesel's cold flow properties. Thus far, most recommendations in cold weather climates call for using blends no higher than 20% biodiesel. According to the National Biodiesel Board, "if it is desired to reduce the cold flow properties of B20 blends…users implement the same solutions as they would with Number 2 diesel fuel—blend with kerosene, use cold flow enhancing additives, turn on fuel filter or fuel line heaters, or store vehicles near or in a building."[53]

While biodiesel is credited with reduced emissions, concerns regarding the possibility of increased nitrogen oxide (NO_x) emissions remain. The tests results themselves remain ambiguous. While the EPA's comprehensive, 168-page analysis of biodiesel emissions reported an increase of up to 10% nitrogen oxide emissions as a result of using pure biodiesel (B100) in a non-adjusted diesel engine, newer technologies show a potential to reverse that effect. Most methods of reducing NO_x emissions levels involve retarding fuel injection timing and adjusting operating engine temperatures slightly. Some additives have been recommended to reduce NO_x emissions below those of conventional diesel fuels.[54] As reported by the National Biodiesel Board, "when blended with B20…a new additive designed by Clean Diesel Technologies (CDT), showed emissions reductions of 5 % NO_x as compared to normal on-highway diesel fuel."[55] Such findings simply illustrate the fact that alterations in manufacturing and

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[51] "Biodiesel and Your Vehicle," Journey to Forever, http://journeytoforever.org/biodiesel_vehicle.html.
[52] "Biodiesel Education: Diesel Fuel Cold Flow Properties," Dept. of Mechanical Engineering, University of Iowa, http://www.me.iastate.edu/biodiesel/pages/biodiesel16.html.
[53] "Cold Flow Impacts," National Biodiesel Board., http://www.me.iastate.edu/biodiesel/pages/biodiesel16.html. p 4.
[54] "NO_x and Biodiesel," Journey to Forever, http://journeytoforever.org/biodiesel_nox.html.
[55] "Study Shows NO_x Emissions Reductions in Biodiesel Blend with Additive," National Biodiesel Board. http://www.biodiesel.org/resources/pressreleases/gen/20040204_ NO_x _additive.pdf.

production fix many of the problems associated with biodiesel. Furthermore, as established by a Department of Energy report examining the impact of biodiesel blends in space heating equipment, "the addition of biodiesel seems to lead to slightly lower carbon monoxide emissions and lower nitrogen oxide emissions as well. The latter, while a welcome result, was somewhat of a surprise because results of biodiesel blends in diesel engines reported in other work indicate either similar or slightly higher NOx levels. Clearly the combustion conditions are very different in the two cases."[56]

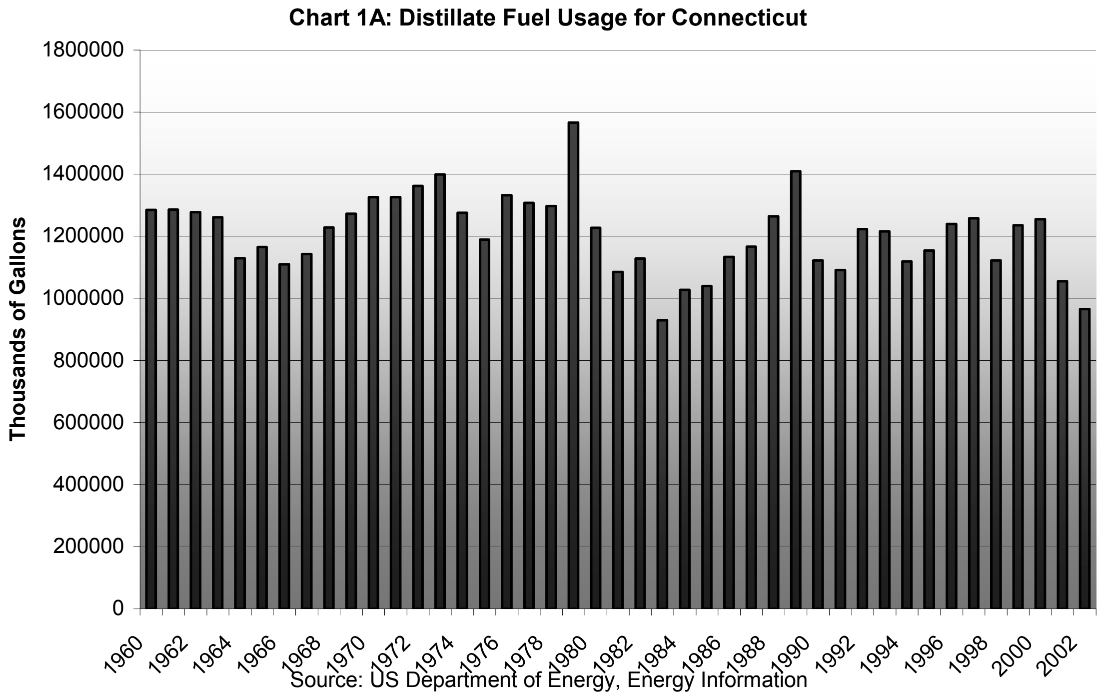
Cost and Benefits

Biodiesel Market

All sources that currently utilize distillate fuel are the potential market for biodiesel in Connecticut. These include (diesel-powered) motor vehicles including construction equipment, power plants, and home heating systems in homes. Distillate fuel consumption for Connecticut exceeded 1.054 billion gallons in 2001 and 964 million gallons in 2002. Thirty-two percent of petroleum used in Connecticut is distillate fuel.[57] Chart 1A provides an historical view of distillate fuel use in Connecticut between 1960 and 2002.

[56] C.R., Krishna, "Biodiesel Blends in Space Heating Equipment," Department of Energy. http://www.biodiesel.org/resources/reportsdatabase/reports/hom/20011201_htg-001_spaceheating.pdf. pg 11.

[57] "Petroleum Profile: Connecticut." http://tonto.eia.doe.gov/oog/info/state/ct.html



The majority of distillate fuel used in Connecticut is for residential heating. Chart 2A displays distillate fuel consumption for 2002 by sector showing that more than 58% of total distillate fuel consumption was for residential heating, while more than 24% was for on-highway diesel fuel consumption.

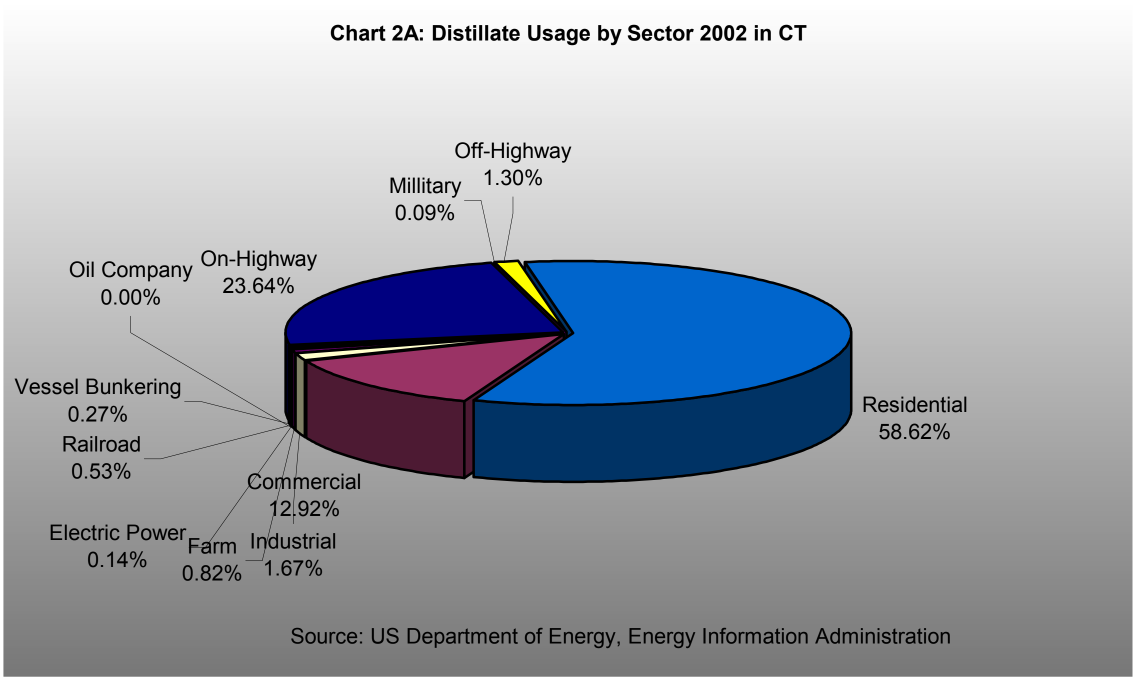
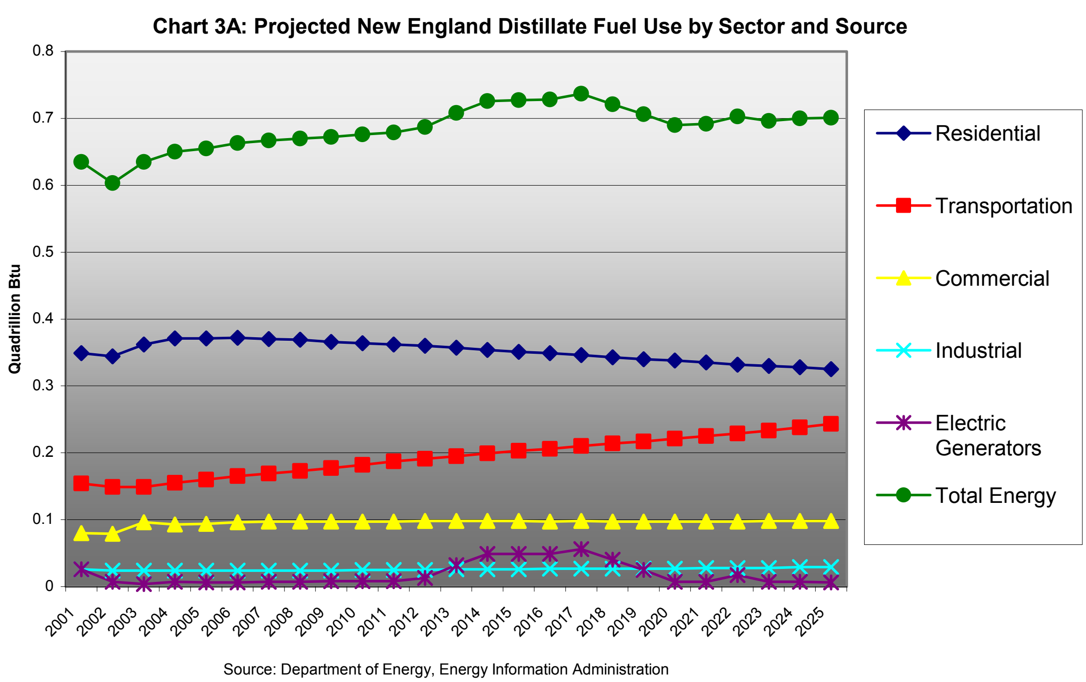


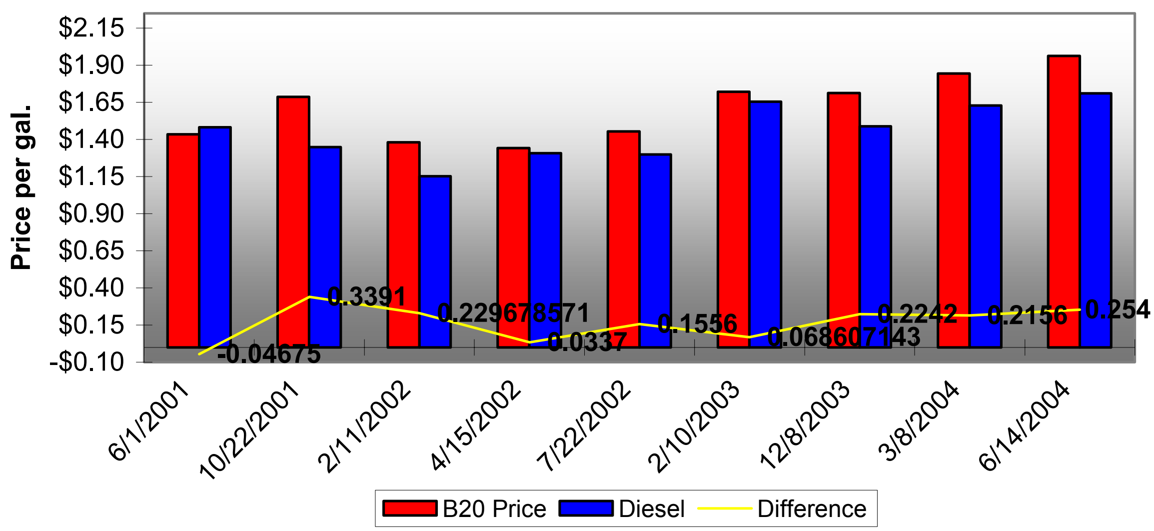
Chart 3A shows that distillate fuel use in both the residential and on-highway sectors is forecasted to increase to 2025 for New England. This suggests that distillate fuel demand will remain strong well into the future.



Costs

One of the largest factors inhibiting the widespread use of biodiesel has been its high price relative to petro-diesel. Pure biodiesel (B100) currently sells for between $2.75 and $4/gal, resulting in a premium for B20 of between $.34 and $.7/gal.[58] Chart 4A shows the price history of biodiesel in terms of B20 against the historical price of diesel.

Chart 4A: B20 vs Diesel



Source: The Alternative Fuel Price Report, US Dept. of Energy

Biodiesel production requires the inputs of oil, alcohol, and a catalyst. Input proportions required for biodiesel production appear in Chart 5A. This paper concentrates on the production of biodiesel using soybean oil exclusively for the feedstock because 90% of American biodiesel production relied upon soybean oil in 2001,[59] accounting for 87% of total inputs. Methanol is 7% of the total input while only 1% of the total input consists of sodium hydroxide. Output consists of unused methanol, methyl ester (biodiesel), fertilizer, and glycerin. Chart 6A shows the process output levels as presented by the National Biodiesel Board.

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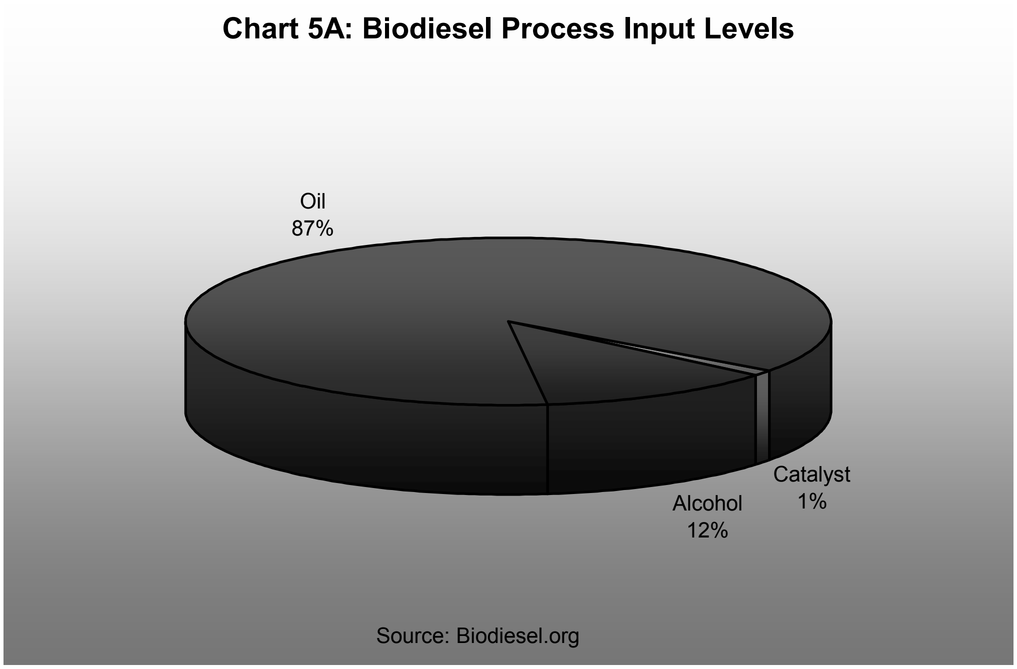
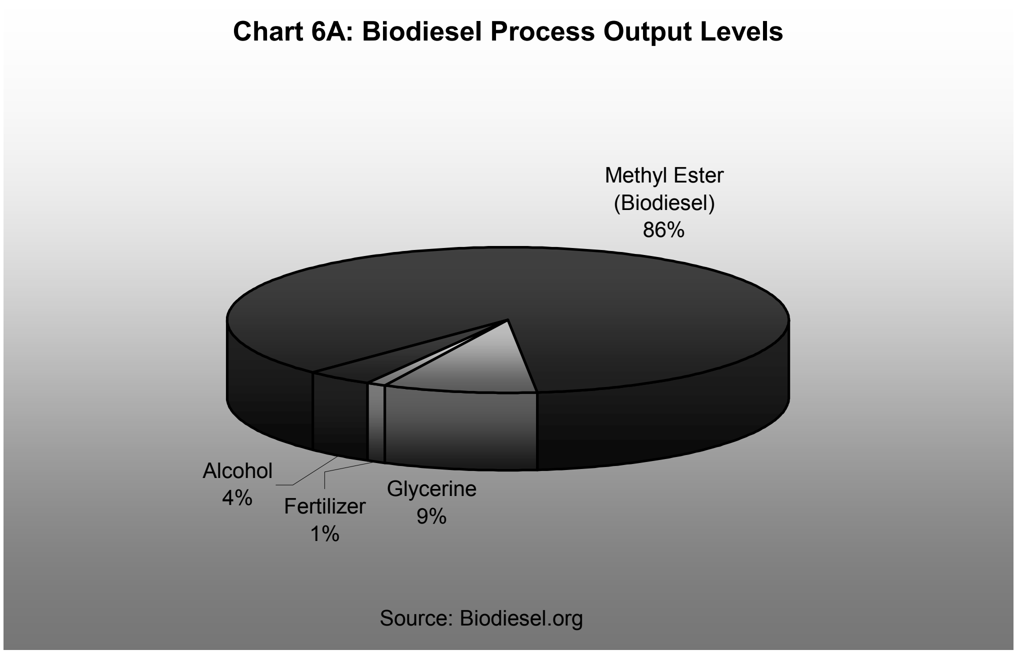
[58] "Market Potential for Biodiesel in Regulated Fleets, Marine Vessels, and Underground Mining Equipment," Booz-Allen&Hamilton. http://www.biodiesel.org/resources/reportsdatabase/reports/gen/19981111_gen-207.pdf, pp II-4.

[59] "What is Biodiesel?" Alternative Fuels Data Center, U.S. Department of Energy.





The cost of producing biodiesel includes the cost of inputs: soy oil, methanol and an alkaline catalyst. Startup costs include a large amount of capital equipment, and the hiring of both skilled and unskilled labor for the production of biodiesel. For the purpose of this study, we will assume that these startup costs are reflected in the actual market price of B20.

Averaging distillate fuel consumption over the period 1993 to 2002, we use the projected price premium of B20 over petro-diesel to calculate the total cost of using B20 instead of all distillate fuel. Using this method to calculate the total cost of using B20 in place of all distillate fuel assumes that the spread (between B20 and petro-diesel) is constant across various types of distillate fuel. This premium is an accurate reflection of the cost of converting to B20 because the adjustment costs associated with using B20 over distillate fuel are negligible. Adjustment costs are limited to the replacement of minor parts (e.g., copper tubing replaced with steel, natural rubber parts with synthetic rubber parts); all else works as well with biodiesel and biodiesel blends as it does with pure diesel.

We calculate an alternative estimate for the cost of converting to B20 by taking the historical average spread between B20 and petro-diesel. This will serve as a more conservative cost estimate. In an attempt to quantify the economic impact of making the switch to biodiesel use, we forecast the price of B20 using crude oil futures and soy oil prices.[60] Therefore, excluding adjustment costs, the actual increased cost from the using B20 instead of distillate fuel is the premium price of B20 above the price of distillate fuel.

Health Benefits

To conduct a cost-benefit analysis for the adoption of biodiesel in Connecticut, we explore the potential health benefits generated from biodiesel use. Reducing diesel exhaust emissions is a major concern for public officials and parents, because numerous health problems arise from conventional diesel fuel use. Although the exposure/dose-response relationship remains unspecified at this time, the EPA ruled diesel exhaust as "likely carcinogenic to humans," recommending serious reductions in permissible diesel exhaust emissions. Additionally, the EPA has found short-term exposure causes "acute irritation (e.g., eyes, nose, bronchial), neurophysiological (e.g., lightheadedness, nausea), and respiratory (e.g., cough, phlegm) symptoms"…[as well as]

[60] See technical appendix A for a more detailed discussion of methodology.

the exacerbation of allergenic responses to known allergens and asthma-like symptoms."[61]

Numerous studies link air pollution and the occurrence of asthma. Additionally, a National Asthma Campaign (since renamed Asthma UK) survey in July 2002 reported that more than 80% of asthmatics reported that air pollution made their symptoms worse.[62] The Surface Transportation Policy Project reports that about one in twenty Americans, or nearly 15 million people, suffer from asthma, and that asthma is the number one reason for children to visit the emergency room and miss school.[63]

With Connecticut ranking as the state 9th most susceptible to cancer risks associated with air quality, examining the public health effects of diesel exhaust becomes an issue of local importance.[64] Seventy-five thousand children and 202,800 adults in Connecticut suffer from asthma, and reports suggest that in one year smog is responsible for 2,500 hospital visits and 100,000 asthma attacks.[65] According to a study conducted in Los Angeles, ozone toxins are the known cause of between 10 and 20% (and up to 50% on bad days) of hospital admissions for respiratory illness.[66] Additionally, the Union of Concerned Scientists has found that the total costs of environmental externalities of United States oil use to be between $54 billion and $232 billion in 1991, or $214 to $920 per capita, with human mortality and morbidity accounting for over 75% of the total environmental costs (as much as $182 billion annually).[67]

Biodiesel reduces many of pure diesel fuel's harmful pollutants including carbon monoxide, particulate matter, nitrogen oxides, and sulfur dioxide. Table 2B shows the decrease in environmental pollutants using B20 in heavy-duty on highway vehicles.

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[61] "Health Assesment Document for Diesel Engine Exhaust," National Center for Environmental Assessment, U.S. Department of Energy. http://cfpub1.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060. pp I-4 to I-5.
[62] "Something in the Air?" Asthma UK, http://www.asthma.org.uk/about/an089.php
[63] "Transportation and Health," Surface Transportation Policy Project, http://www.transact.org/library/factsheets/health.asp.
[64]http://www.scorecard.org/env-releases/hap/rank-states.tcl
[65] "Connecticut's Air is Not Healthy," Clean Car Alliance and CT Environmental Fund, http://www.cfenv.org/PDFs/11-11-03%20Health%20Issues.pdf
[66] "Oil Slickers: How Petroleum Benefits at the Taxpayer's Expense," Institute for Local Self-Reliance, http://www.ilsr.org/carbo/costs/truecosttoc.html.
[67] "Subsidizing Big Oil," Union of Concerned Scientists, http://www.ucsusa.org/clean_vehicles/archive/page.cfm?pageID=817.

Table 2B	
Emission	*B20*
Carbon Monoxide	-11%
Particulates	-10.1%
Nitrogen Oxides	2%
Sulfur Dioxides	-20%[68]
Source: EPA, "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions."	

Using B20 substantially reduces emissions of particulate matter, sulfur dioxide and carbon monoxide, yet slightly increases emissions of nitrogen oxides. A 2003 study found that B20 used in home heating units reduces nitrogen oxide emissions by 20%, sulfur dioxide emissions by 83%, carbon dioxide emissions by 20%, and reduces particulate matter emissions.[69] It is important to note that the majority of the reduction in sulfur dioxide emissions was a result of using low-sulfur #2 heating oil. However if standard #2 heating oil is used there would be an expected reduction of 20% in sulfur dioxide emissions. It is likely that the reduction in NOx results from continuous combustion in home heating systems relative to the intermittent combustion in a diesel engine. The previously listed studies serve as a basis for our estimates of reductions in emissions among different emission sources.

Carbon Monoxide

Carbon monoxide (CO) is an odorless, colorless gas produced by the incomplete burning of carbon in the fuel combustion process. Carbon monoxide in sufficient concentration can have adverse effects on the cardiovascular and the central nervous system. Cardiovascular effects include chest pain and inability to exercise and low levels of CO can cause clogged arteries or congestive heart failure in patients with existing heart problems.[70] High levels of CO can affect healthy individuals through lowered manual

[68] U.S. Department of Energy, Energy Efficiency and Renewable Energy
[69] Batey, John E. "Combustion Testing of Bio-diesel Fuel Oil Blend in Residential Oil Burning Equipment," July 2003.
[70] http://www.epa.gov/air/urbanair/co/hlth1.html

dexterity, vision problems, and decreased ability to work. Carbon monoxide emissions also contribute to asthma, dysrhythmias, and obstructive lung disease.

Particulate Matter

Particulate matter (PM) includes dust, soot, smoke or liquid in the air. Large particles can be visible, but the non-visible, smaller particles are more dangerous. Diesel exhaust contains significant levels of small particulate matter, which due to their small size, can pass through the nose and throat passages and cause respiratory illness. Diesel engines contribute over 20% of the total directly emitted small particulate emissions in New England.[71] Epidemiological studies have shown an association between diesel particulate matter and an increased risk of cancer.[72] Particulate matter contributes to over 15,000 premature deaths annually nationwide. Studies have shown that PM contributes to many health problems including aggravated asthma, chronic bronchitis, decreased lung function, and premature death.[73]

Nitrogen Oxides

Nitrogen oxide compounds create ground level smog that can cause adverse health impacts in children, people with lung diseases and people working outside. Adverse health impacts include damage to lung tissue and lung function reduction as well as premature death.[74] Small particles can cause or worsen respiratory disease such as emphysema and bronchitis, as well as aggravate existing heart disease.

Sulfur Dioxide

Sulfur dioxide (SO_2) results from the combustion of fuels containing sulfur. Petroleum based fuels contain high levels of sulfur. High levels of SO_2 can cause temporary breathing problems for people with asthma and lung problems and long-term exposure can cause respiratory illness and exacerbate heart disease symptoms.[75] Exposure to sulfur dioxide can cause respiratory disease, difficulty breathing and premature death. SO_2 is also a major component of acid rain.

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[71] http://www.epa.gov/region01/eco/diesel/health_effects.html
[72] http://www.epa.gov/region01/eco/diesel/health_effects.html
[73] http://www.epa.gov/air/urbanair/pm/hlth1.html
[74] http://www.epa.gov/air/urbanair/nox/hlth.html
[75] http://www.epa.gov/air/urbanair/so2/hlth1.html

Other benefits for Connecticut

Connecticut would benefit from using B20 as an alternative fuel source to increase its independence from international fuel sources. Connecticut could, to some extent, insulate itself from fuel price shocks and the building price pressures that come with world growing demand. By creating an alternative to petro-based fuels, Connecticut would also capture both ecological and agricultural benefits. Unused agricultural land could be re-sown with oilseed crops, putting farmers back in business, and preserving open-space. Therefore, the projected benefits as depicted in this paper are conservative because it does take into account either ecological and agricultural benefits, nor the increased stability created through reduced dependence oil.

Using 1999 emissions inventories for the Connecticut, we calculate a reduction in the total emissions inventory as a result of switching to B20 from distillate fuel. Using the studies previously cited, we estimate a reduction in emissions' inventories for various sources including heavy-duty on-highway use, home heating oil use, and non-road diesel use. We exclude light-duty on highway sources due to uncertainty in testing results and a lack of appropriate data.[76] In order to quantify the benefits created through decreased pollution emissions, we estimate dollars per ton of pollutant emitted, and multiply this by the reduction in emissions from switching to biodiesel from distillate fuel. We estimate the costs per ton for various health problems created by pollutants including acute bronchitis, asthma attacks, and cardiovascular hospital admissions among others.[77] In this way, we estimate the averted cost of adverse health effects with the use of biodiesel for NOx, SO_2, and PM. Averted health costs were the most tangible benefits available for analysis.

We made simplifying assumptions to facilitate our analysis. We assume that the averted health costs in dollars per ton are the same for heavy duty and non-road engines, as well as for heating oil. Despite a lack of available data on health costs for B20 emissions in home heating oil units, we assume that averted health costs (benefits) are nevertheless consistent for all uses. Further uncertainty arises because the estimates for

[76] For a study on biodiesel use in light-duty trucks see "Bioblended Fuel for Use in Light Duty Compression Ignition Engines," May 1997.
[77] For a more complete description of methodology used see "Estimated NOx, SO2, and PM Emissions Health Damages for Heavy Duty Vehicle Emissions," Dr. Bryan Hubbell, April 22, 2002

the dollar per ton reductions we used to calculate averted health costs are derived from estimates on a national level.[78] By using this model on a regional basis, we increase the uncertainty of the benefit estimations obtaining only a more uncertain "ballpark" estimation than the model projects on a national level. Furthermore, there may be significant variation in the $/ton/person amount for any specific ton of emission reductions. The magnitude of this bias is unknown. Because of lack of data on non-road biodiesel emissions, we assume that the only change in emissions for non-road engines is a 20% reduction in sulfur emissions when using B20, because biodiesel contains no sulfur. We also exclude any changes in particulate matter emission in home heating oil because of lack of emission characteristics.

Table 3A: CT Health Benefits (Averted Costs for Projected Spread) by Source (2004 Dollars)

Source and Pollutant	**B20 Benefits**	**B20 Benefits per cap**
Heavy Duty Diesel Trucks		
PM	$43,647,891	
NOX	-$9,892,147	
SO2	$3,944,998	
Heavy Duty Diesel Truck Total	***$37,700,742***	***$10.82***
Home Heating Oil		
PM	NA	
NOX	$11,445,754	
SO2	$43,275,354	
Home Heating Oil Total	***$54,721,109***	***$15.71***
Non-Road Diesel Engines		
PM	NA	
NOX	NA	
SO2	$8,466,823	
Non-Road Diesel Total	***$8,466,823***	***$2.43***
Total Benefits	***$100,888,674***	***$28.96***
Total cost	**($81,331,075)**	**($23.35)**
Net Benefit to Connecticut	***$19,557,599***	***$5.61***

[78] For a complete treatment of the estimation method used see "Estimated NOx, SO_2, and PM Emissions Health Damages for Heavy Duty Vehicle Emissions," Dr. Bryan Hubbell, April 22, 2002.

Table 3A summarizes the averted health costs over all pollutant sources using the ***forecasted*** B20-petrodiesel spread analysis. Summing up the benefits for various sources gives us Connecticut's net benefit/cost associated with replacing distillate fuel with B20. Under the assumptions listed previously, the net benefit represents a "ballpark" estimate. These results are highly dependent on the future prices of the selected inputs. Therefore, the results may change given any deviation in the cost of the selected inputs used in our analysis. Table 3A shows that given the difference between costs as calculated by the predicted spread between B20 and distillate fuel prices and the averted health costs (benefit), we find a net benefit of almost $20 million.

Table 3B: CT Health Benefits (Averted Costs for Average Spread) by Source (2004 Dollars)		
Source and Polutant	**B20 Benefits**	**B20 Benefits per cap**
Heavy Duty Diesel Trucks		
PM	$43,647,891	
NOX	-$9,892,147	
SO2	$3,944,998	
Heavy Duty Diesel Truck Total	***$37,700,742***	***$10.82***
Home Heating Oil		
PM	NA	
NOX	$11,445,754	
SO2	$43,275,354	
Home Heating Oil Total	***$54,721,109***	***$15.71***
Non-Road Diesel Engines		
PM	NA	
NOX	NA	
SO2	$8,466,823	
Non-Road Diesel Total	***$8,466,823***	***$2.43***
Total Benefits	***$100,888,674***	***$29.26***
Total cost	***($185,899,600)***	***($53.37)***
Net Benefit	***($85,010,925)***	***($24.11)***

Table 3B gives a net benefit/cost analysis for an ***average*** B20-petrodiesel price spread reflecting a three-year average premium of B20 relative to diesel. The average spread obtained from the historical price difference between biodiesel and petro-diesel is used as an alternative to the ***projected*** spread to more conservatively estimate the benefits from the use of B20 instead of petro-diesel. If this future price of B20 converges towards a three-year average of $0.16 over the price of diesel, there will be a net loss associated with the adoption of B20. This represents a more conservative estimate that is not based on forecasting methods but rather on an historical approach. These results are conservative because they do not consider the projected decrease in the price of soybean oil as well as projected crude oil prices. More importantly, the measured benefits do not include agricultural or ecological benefits and exclude benefits that exist with decreased dependence on foreign oil. However, absent of the projected decrease in soybean oil prices the results in Table 3B represent the next best estimate.

Legislation

Federal environmental legislation has opened the way for biodiesel to become more competitive with petroleum fuel. The Clean Air Act Amendments of 1990 (CAAA P.L. 101-549), adopted in the face of growing concern surrounding acid rain, urban air pollution, and toxic emissions, revealed an increasing demand for finding alternative and less environmentally damaging fuel sources. The law gives new power to the EPA in enforcing clean air policies and provides market incentives for complying with and exceeding state-mandated emissions standards.[79]

Furthermore, the Energy Policy Act of 1992 (EPACT, P.L. 102-486), introduced to reduce the country's dependence on foreign oil, requires certain federal fleets to acquire alternative fuel vehicles (AFV). The law stipulates that by fiscal year 2000, 75% of federal department fleets' light-duty vehicles (LDV) must be AFV's. Through a combination of AFV acquisitions and increased efficiency in remaining vehicles, agencies are required to reduce petroleum consumption by 20% by 2005, from 1999 levels. An important step in expanding the use of biodiesel, the Energy Conservation Reauthorization Act of 1998 amends the 1992 policy by further stipulating that these agencies are allowed one AFV credit for every 450 gallons of pure biodiesel (B100)

[79] "Clean Air Act," Environmental Protection Agency, http://www.epa.gov/oar/oaq_caa.html/.

purchased for use in diesel vehicles over 8,500 lbs. These credits can account for up to 50% of each agency's required AFV credits.[80]

Under the Clean Bus and Truck Rule, passed by the EPA in December 2000, refiners will be required to start processing an ultra-low sulfur diesel fuel, which reduces sulfur content from 500 ppm to 15 ppm, by June 2006. These requirements are mandated to be adopted by federal truck and bus fleets by September 2006. Sulfur acts as a lubricant in fuel, and ultra-low sulfur petro-diesel loses much of its lubricity. Stanadyne Automotive Group, one of the country's leading manufacturers of diesel fuel-injection pumps, sent a note to the EPA during the comment period on the new low sulfur rule, suggesting that biodiesel be used as the additive to increase lubricity in the low sulfur fuel.[81] Biodiesel, as discussed earlier, has high lubricity: a 1 % biodiesel blend (B1) increases lubricity of conventional diesel fuel by up to 65%.

When fully implemented, the Clean Truck and Bus Rule is expected to increase conventional diesel costs by approximately 4.5 cents to 5 cents a gallon. The rule also requires all new heavy-duty trucks and buses add particulate filters and NOx reduction controls, with a phase-in approach starting in 2007 and lasting through 2010.[82] In May 2004, the EPA further expanded the low sulfur diesel rule to apply to off-road engines, including the majority of construction, mining, and agricultural equipment.[83] There have been proposals to extend the rule to marine diesel engines and locomotives as well, increasing the potential demand for biodiesel as a fuel additive. Connecticut fleets currently use biodiesel to meet a number of their Clean Air Act requirements. Since 2000, the Connecticut Bureau of Highway and Engineering Operations used 326,000 gallons of B20 fuel, with just under 100 vehicles running on the blend. The department has noted, "it has worked out very well during all four seasons of road maintenance activities," citing the only possible drawback to the use of biodiesel fuel being the relatively higher cost.[84]

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[80] "Energy Policy Act," U.S. Dept. of Energy, http://www.eere.energy.gov/vehiclesandfuels/epact/.
[81] "EPA Off-Road New Sulfur Rule Could Spur Greater Biodiesel Use," National Biodiesel Board, http://www.biodiesel.org/resources/pressreleases/gen/20040511_EPA_Off-road_low_sulfur.pdf.
[82] "Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements," Environmental Protection Agency, http://www.epa.gov/otaq/regs/hd2007/frm/f00057.pdf.
[83] "Clean Air Nonroad Diesel: Final Rule," Environmental Protection Agency, http://www.epa.gov/nonroad-diesel/2004fr.htm
[84] Baron, Richard. Connecticut Department of Transportation, Personal Interview.

Some politicians are pursuing a biodiesel tax credit, and it currently remains part of the Senate Jobs Bill as of May 2004. If the bill ultimately passes into law, it would stipulate a one-penny excise tax credit per percent of biodiesel used in a blend up to 20%, and would be available to diesel excise taxpayers and other fuel distributors who market biodiesel blends. A similar credit is present in several energy and transportation bills awaiting review as well.[85] In July 2004, Vice-President Dick Cheney spoke in favor of the energy bill containing the biodiesel tax credit that has stalled in Congress. Cheney remarked in a speech in Columbia, MO, near the site of the National Biodiesel Board's headquarters, that "the bill includes within it some very significant incentives for biodiesel and ethanol…[which will] reduce the extent to which we're dependent on foreign sources of oil for our basic transportation. It's a very good piece of legislation." Government support for the production and consumption of biodiesel remains essential for achieving a stable and expanding market in the future.[86]

In June 2004, an Energy Independence Act was proposed that could potentially increase nation-wide use of biodiesel fuel, as well as other sources of renewable and sustainable energy. Among other energy-saving and tax exemption recommendations, the bill calls for the creation of a federal Renewable Fuel Standard that would mandate the increased use of renewable fuels over time, as well as a provision for permanent tax credits for electricity derived from wind, ethanol, and biodiesel sources and a requirement that all federal fleets use ethanol and biodiesel fuel when economically feasible.[87]

Volunteer Programs

Sponsored by the EPA, several volunteer programs support an increase in the use of biodiesel fuel. These programs, including the Clean School Bus Program, the Voluntary Retrofit Program, and the Smartway Transport Partnership advocate the use of cleaner transportation around the country. The Clean School Bus Program, for which Congress allocated $5 million in 2004, provides grants to school districts around the

[85] "Senate Passes Jobs Bill Including Biodiesel Tax Provisions," National Biodiesel Board, http://www.biodiesel.org/resources/pressreleases/gen/20040512_fsc_bill_passes_senate.pdf.
[86] "Vice President Confirms Need for Biodiesel Tax Incentive," National Biodiesel Board, http://www.biodiesel.org/resources/pressreleases/gen/20040721_Cheney_Bush.pdf.
[87] "Biodiesel Industry, Soybean Leaders Commend Rep. Nussle for Energy Independence Act," National Biodiesel Board, http://www.biodiesel.org/resources/pressreleases/gen/20040628_NussleBill2.pdf.

country in an effort to reduce school bus emissions. Many of the school district programs include the implementation of particulate matter and NOx filters, as well as the use of biodiesel blends in some instances. By advocating stricter regulations and better equipment to keep air quality high, the program increases awareness surrounding public health issues and supports the use of biodiesel blends in school buses.[88]

The Voluntary Diesel Retrofit Program illustrates the EPA's efforts to help curb diesel emissions in the immediate future, before full passage of the new diesel emissions standards, defined by the Clean Truck and Bus Rule (to begin in 2006 and 2007). With funding of $1.5 million, the EPA provides grants to counties and cities around the country interested in meeting the clean standards before the official enactment of the law. The grants, begun in 2003, aided several areas in implementing better clean air technology in a number of on-road and off-road fleets.[89]

The Smartway Transport Partnership is an association among various freight industry sectors and the EPA that establishes incentives for fuel efficiency improvements and greenhouse gas reductions among participating businesses. By creating these partnerships, and establishing idle-free corridors around the country and maximizing rail efficiency, the EPA estimates that by 2012 the United States will see a reduction between 33 - 66 million metric tons of carbon dioxide (CO_2) emissions and up to 200,000 tons of nitrogen oxide (NOx) emissions per year. The EPA predicts the initiative will result in fuel savings of up to 150 million barrels of oil annually.[90] As awareness concerning environmental and public health issues surrounding clean air continues to grow, biodiesel has the ability to help shape the changing marketplace.

Another program, the Clean Cities Coalition, sponsored by the Department of Energy, coordinates the purchase of alternative fuel vehicles (AFV's) between federal, state, municipal, and private fleets of participating coalitions. Each region must develop a fuel implementation program that focuses on initiating new public policy and promotes AFVs, fuel blends, idle reduction, hybrids, and fuel economy in designated communities. The program provides funding to communities looking to purchase new AFV's. Since

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[88] "Clean School Bus USA." Environmental Protection Agency, http://www.epa.gov/cleanschoolbus/.
[89] "Voluntary Diesel Retrofit Program," Environmental Protection Agency, http://www.epa.gov/cleanschoolbus.
[90] "Smartway Transport Partnership," Environmental Protection Agency, http://www.epa.gov/otaq/smartway/swplan.htm.

1993, eighty coalitions have been launched in the United States, with over 4,800 stakeholders participating.[91] While the program establishes great potential for the expanded use of biodiesel and other alternative fuels in cities around the United States, some have found that, thus far, the programs have come up short. According to a Booz-Allen & Hamilton Study completed for the United Soybean Board, "while the Clean Cities Coalition Program has been successful in securing federal funds and drawing attention to alternative fuel efforts in a city, purchases of alternative fuel vehicles by Clean Cities participants cannot be guaranteed. The number of alternative fuel vehicles actually acquired under the Clean Cities program has not met expectations."[92] Connecticut currently has four Clean Cities coalitions: Norwich, New Haven, Connecticut Southwestern Area (Norwalk), and Capital Clean Cities of Connecticut, all of which could be expanded to promote the use of biodiesel statewide.

Initiatives Taken by Other Regions

Around the country and abroad, there have been many initiatives undertaken in order to make the environment cleaner for current and future generations. Some of these initiatives have focused on renewable energy sources, some utilizing biodiesel. Several states have started to promote the use of biodiesel through local government undertakings and private ventures. The need to be more environmentally responsible is not isolated to the United States. Europe is more progressive than the United States in terms of promoting the use of biodiesel and other alternative energy sources. In France, all diesel fuel sold contains 5 % biodiesel, and in Germany, there are 1,500 gas stations offering biodiesel.[93] There is a growing worldwide trend towards becoming more environmentally responsible. This section discusses the various efforts of states in the Northeast to implement cleaner and more efficient use of petroleum and to utilize renewable fuel sources.

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[91] "Clean Cities Program," U.S. Department of Energy, http://www.eere.energy.gov/cleancities/coalitions.html.
[92] "Market Potential for Biodiesel in Regulated Fleets, Marine Vessels, and Underground Mining Equipment," Booz-Allen&Hamilton, http://www.biodiesel.org/resources/reportsdatabase/reports/gen/19981111_gen-207.pdf. pp II-10.
[93] "Fill 'Er Up Full of Beans," Wired Online, November 22, 2003.

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort of New England and Mid-Atlantic states to work together to reduce greenhouse gas emissions. Using cap and trade and a market based emissions allowances trading program, the region initially is concentrating on reducing carbon dioxide emissions in the energy sector, then intends to move towards reductions in emissions from other sources. Gradually phasing in an interstate trading system of greenhouse gas allotment permits, the initiative is a step towards regional environmental accountability. The use of biodiesel could be used to reduce these greenhouse emissions and as trading allowance permits force polluters to incur pollution costs, and a market for emission reduction develops, biodiesel should become more cost competitive.

Massachusetts

In 1997, the Massachusetts State Legislature defined biodiesel as a biomass energy source that is in the class of energy sources denoted as renewable energy.[94] Renewable energy was classified as a primary energy source. Biodiesel fuel then became a primary energy source in the State of Massachusetts. That same year (1997), the legislature created the Massachusetts Renewable Energy Trust Fund. The purpose of this fund is to begin a "series of initiatives which exploits the advantages of renewable energy in a more competitive energy marketplace by promoting the increased availability, use, and affordability of renewable energy and by fostering the formation, growth, expansion, and retention within the commonwealth of preeminent clusters of renewable energy and related enterprises, institutions, and projects, which serves the citizens of the commonwealth."[95]

The Massachusetts Renewable Energy Trust Fund (the Fund) has been allotted money that can be drawn upon for various purposes. These funds advance the public interest by creating a portfolio of sound investments in ventures utilizing and developing better renewable energy technologies. The legislature set forth that the public interest should be met through "the development and increased use and affordability of renewable energy sources,…, the protection of the environment and the health of the citizens…, the

[94] Acts of 1997
[95] Subsection C, Section 20, Chapter 25, amended in Section 37 of Chapter 164 of the Acts of 1997.

stimulation of public and private investment in … renewable energy and related enterprises, institutions, and projects."[96] The Fund will make grants, contracts, and other investments for the public wellbeing.

The Fund wasted little time in fulfilling its goals and objectives. It funds grants and feasibility studies for organizations to investigate biodiesel-fueled projects. The New England Wildlife Center received a sizeable grant in 2002 to study biodiesel-fueled cogeneration to meet the majority of the building's energy needs.[97] During the same year, the Allston-Brighton Community Development Corporation received a grant for a feasibility study allowing the Corporation to select intelligently a biodiesel cogeneration system for its low-income housing project.[98] The following year, the Beals Memorial Library in Winchendon received a grant that allowed a team to study the possibility of adding a low-head hydroelectric microturbine system to be used in conjunction with biodiesel fuel in order to maintain the electric and heating facilities of the complex.[99] The Fund is not the only government agency that is helping to advance the cause of biodiesel, however.

The Massachusetts Port Authority runs biodiesel fuel in more than 30 shuttle buses at Logan Airport, and the MBTA has found it is possible to save approximately $14 million over a ten-year period (starting in 1996) by using biodiesel fuel in its fleet of buses compared to purchasing new vehicles in order to meet federal standards.[100] The City of Worcester participated in a biodiesel demonstration that lasted approximately six weeks in which ten buses were powered with biodiesel fuel.[101] Data collected from these ten vehicles was compared to data taken from other fuels used by the same buses. The final comparisons have yet to be released.

There have also been private initiatives in Massachusetts to promote biodiesel fuel. The Pioneer Valley Biodiesel Cooperative formed in Greenfield during April

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[96] Subsection C, Section 68, Chapter 164 of the Acts of 1997.
[97] http://www.mtpc.org/Project_lst_rslt.asp?ID=453.
[98] http://www.mtpc.org/Project_lst_rslt.asp?ID=405.
[99] http://www.mtpc.org/Project_lst_rslt.asp?ID=437.
[100] "Biodiesel Fuel Made of Soy Beans and Vegetable Oils Could Clean up Bus Emissions," The Boston Globe, November 21, 1996.
[101] Schumacher, L. G. and J.A. Weber (1994). "Collection and Collation of Performance Data from Urban Mass Transit Biodiesel Demonstrations," *Proceedings of an Alternative Energy Conference, American Society of Agricultural Engineers Summer Meeting*. Kansas City, MO

2001.[102] The Co-op's mission promotes the use of biodiesel, builds demand through education and marketing, and supplies its members and surrounding organizations with biodiesel fuel. This organization is still undergoing the necessary steps in order to be fully recognized as a cooperative; however, there is already a plan to erect a 250,000 gallon-per-year biodiesel plant in western Massachusetts. The Co-op is active in the production and regional distribution of biodiesel fuel through operations based in Holyoke.

Rhode Island

Connecticut's eastern neighbor has recently begun to play an important role as an environmental champion through its uses of biodiesel fuel. In January 2004, the Rhode Island General Assembly introduced an act that would remove biodiesel fuel from the list of fuels that would be affected by the motor fuel tax.[103] As stated previously, biodiesel fuel is more expensive than petro-diesel fuel. This bill would allow biodiesel to become and remain price-competitive with its petro-diesel counterpart.

Various state agencies have also begun to promote biodiesel. The REC Fleet Fueling Services operates a gas station, which in August 2003 opened the first public biodiesel refueling pump in Rhode Island.[104] In order to induce owners of truck and bus fleets to purchase biodiesel, the station received a $7,000 grant from the Rhode Island State Energy Office stating that the grant originated in the United States Department of Energy. The Rhode Island Economic Development Corporation, along with a small group of investors (World Energy and Baker Commodities), is providing financial assistance to Stephen Woerner' company, Northeast Bio-Energy Corp., to erect a $3 million plant in the capitol, Providence. This plant will produce biodiesel fuel from restaurant grease. Sayer's Wharf in Newport is running a subsidized project, in which pure biodiesel (B100) has been used in their water taxis since 1999.[105]

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[102] http://www.spinninglobe.net/bioupdate6.htm.
[103] State of Rhode Island General Assembly, "An Act Relating to Motor Vehicles – Motor Fuel Tax," January Session 2004, http://www.rilin.state.ri.us/billtext/billtext04/senatetext04/s2988.htm.
[104] Barmann, Timothy C., "Gas-Price Spikes Fuel Interest in Biodiesel," The Providence Journal, Thursday, August 28, 2003.
[105] Edie Weekly Summaries, "Marine Use of Biofuels Floated as Florida's First Biodiesel Marina Opens for Business," August 3, 2002, http://www.edie.net/news/Archive/5267.cfm.

Though the initiatives mentioned above are great leaps forward for Rhode Island in terms of environmental responsibility, nowhere else in the state has there been more effort than in the City of Warwick to promote biodiesel. On February 2, 2004, the United States Environmental Protection Agency (EPA) announced it would award a $15,000 grant to the Rhode Island Department of Environmental Management (DEM).[106] With this grant, it will be possible for the DEM and the New England Asthma Regional Council (ARC) to prepare information packets about the risks that petro-diesel-powered school buses pose to children. This effort is part of the Clean, Green School Bus Awareness Program, whose main purpose is to educate individuals about the severe risks petro-diesel exhaust poses. Since March 2003, the Warwick school district has been involved in a one-year pilot project in which the district school bus fleet uses a biodiesel/petro-diesel fuel mixture.

Warwick has become the first city in the country to heat its schools with biodiesel fuel. Robert Cerio, Warwick Public Schools Energy Educator/Manager, proposed a three-year program to test a group of four schools using regular heating oil and blends of biodiesel fuel.[107] The program was conducted using various blends of biodiesel fuel in the boilers in three of the four schools, with the fourth used as a control. Cerio found that the B20 blend performed much better in terms of emissions and burning efficiency when compared to the control school. Starting in May 2003, phase two of the project began with the use of B20 fuel in various boilers across the school district. If this project is successful, all thirteen school buildings using heating oil will switch to B20.

Warwick found a way to make this initiative cost effective by investing in oil futures that alleviated the cost of using B20. This demonstrates that despite the higher cost of using B20, there are means available to reduce the cost and make widespread use economically feasible. The Warwick school system is implementing a curriculum that focuses on this cleaner burning alternative. The school system amended its curriculum with a portion based on a program created by the Northeast Sustainable Energy Association called Cars of Tomorrow and the American Community.[108] This should

[106] EPA Press Release, "EPA Awards $15,000 to Rhode Island for Clean, Green School Bus Awareness Program," http://www.epa.gov/region1/pr/2004/feb/040207.html,
[107] www.rebuild.org/attachments/successstories/RhodeIslandBiodiesel.pdf.
[108] "Back to School with Biodiesel," National Biodiesel Board, News release: October 6, 2003.

produce a new generation of citizens keenly aware of the benefits of cleaner, more efficient, renewable fuel.

New Jersey

Prior to 2002, the State of New Jersey initiated many programs in order to promote the use of biodiesel fuel. In terms of legislation, there was not much notice of biodiesel fuel until 2002. However, in 2002, Reed Gusciora initiated a bill that would make biodiesel fuel and any blend thereof exempt from all motor fuel taxes.[109]

State agencies within New Jersey have been promoting biodiesel fuel usage. The Office of Clean Energy initiated the Biodiesel Fuel Rebate program in July 2003[110]. This program uses $500,000 collected from the Petroleum Overcharge Reimbursement Fund to give reimbursements to state and local government agencies that decide to fuel government vehicles with biodiesel fuel. A total of $184,400 has already been allotted to five contracts as of March 1, 2004. The five participants (using B20) taking part in the program are the Medford Township school district, Jersey City, William Paterson University, Teaneck Township, and the Port Authority of New York and New Jersey. From figures that are available, the Medford Township will be reimbursed for biodiesel fuel up to the amount of 50,000 gallons per year; William Paterson University will be reimbursed for up to 12,000 gallons over a two-year period; Jersey City will be reimbursed for up to 104,000 gallons over a two-year period; and, the Port Authority will be reimbursed for approximately 50,000 gallons per year.

In July 2003, the Office of Clean Energy enacted the Alternative Fueled Vehicles Infrastructure program. One half million dollars from the Petroleum Overcharge Reimbursement Fund funds this program , that will be given to applicants to cover up to 50% of the costs necessary to purchase and implement the infrastructure necessary to refuel AFVs. As of 2004, there is $319,000 available for the reimbursement of state and local government agencies that refuel their vehicles with biodiesel. As of March 1, 2004 there have been two contracts signed for the available rebates.

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[109] Gusciora, Reed, Bill Number A3084, State of New Jersey Legislature, December 12, 2002.
[110] New Jersey Clean Cities Program, 2004 Program Plan Update, 2004.

Warwick, Rhode Island is not the only school district to use biodiesel fuel in its fleet of school buses. The Medford Township school district began a program in November 1997[111] using biodiesel fuel in approximately half of the buses in its fleet.[112] This project was made possible by a $115,000 grant from the U.S. Department of Energy to the New Jersey Board of Public Utilities.[113] Since the inception of this program, the school district has been able to fuel forty-four of its school buses with B20.[114] The director of operations and technology for Medford Township, Joe Biluck Jr., has good things to say about the program.[115] He has said that there has been no down time since using biodiesel, the systems have never gelled up, and the district has been able to use this fuel even in temperatures of eleven degrees below zero.

The New Jersey Transit (NJT) system supports biodiesel use. In late 1997, the NJT began a four-month test program in which it used B20 in nineteen buses.[116] Using money from a grant made by the United Soy Board, the National Biodiesel Board was able to provide biodiesel fuel to the NJT free of charge. Through the program, they concluded that the fuel economy of the bus fleet had not changed dramatically, and the overall performance of the bus fleet had not diminished.[117] Not only has the NJT participated in this pilot program, but Robert Shin and James Weinstein, New Jersey's Commissioners of the Environment and Transportation, respectively, announced in June 2000 that World Energy would be supplying B20 to the state garage in Trenton, and this would be the only fuel used in the garage.[118] Between the time of the press release and

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[111] "Local Clean Bus Initiatives," Environmental and Energy Study Institute, January 22, 2004, <http://www.eesi.org/programs/cleanbus/cleanbuslisting.htm> July 27, 2004.
[112] "Medford, New Jersey School District," National Biodiesel Board, http://www.biodiesel.org/resources/users/stories/medfordnj.shtm, July 27, 2004.
[113] Clean Cities Program, "Medford Township New Jersey," Energy Efficiency and Renewable Energy, April 22, 2003, http://www.eere.energy.gov/cleancities/progs/new_success_ddown.cgi?64.
[114] "Local Clean Bus Initiatives," Environmental and Energy Study Institute, January 22, 2004, http://www.eesi.org/programs/cleanbus/cleanbuslisting.htm, July 27, 2004.
[115] "Medford, New Jersey School District," National Biodiesel Board, http://www.biodiesel.org/resources/users/stories/medfordnj.shtm, July 27, 2004.
[116] Soy and Human Health, "NJ Transit Fueling Buses with Soy Oil Blend, Developed in," University of Illinois Extension, December 13, 1997, http://www.ag.uiuc.edu/archives/experts/health/1997/0748.html, July 27, 2004.
[117] New Jersey Transit Demonstration, USB Project Number 96-6091, Final Report, http://www.biodiesel.org/resources/reportsdatabase/reports/tra/19980601_tra-002.pdf, July 27, 2004.
[118] Press Release, "World Energy Biodiesel Fuels New Jersey Transit Future," National Biodiesel Board. June 30, 3000 <http://www.biodiesel.org/resources/pressreleases/tra/20000630_newjersey.pdf> July 27, 2004

2001, the garage was expected to consume approximately 375,000 gallons of B20. The decision to use the B20 was weighed against different strategies using other alternative fuels. With most of the other alternative fuel strategies, the NJT would have been forced to purchase new buses. Because B20 can be used in an existing fleet without modification, fueling the 150 buses using this garage will cost half the purchase price of one new bus.

New Hampshire

New Hampshire has been making great strides in promoting biodiesel as an alternative, environmentally friendly fuel. The first biodiesel station in the state opened in West Chesterfield in December 2003.[119] World Energy Alternatives will supply this station with B20. Since the station's opening, the president of the company was quoted that it sells approximately 4 thousand gallons per month.[120] One year later, it appears that New Hampshire is taking a larger step forward in its biodiesel promotion. On April 2, 2004, Rymes Oil announced that the first bulk biodiesel terminal would be opening in the town of North Stratford[121] and be distributed to customers in its pure form (B100) and in multiple blends. Simultaneously, B20 will be distributed to five fueling stations throughout the state. This announcement marks one of the first attempts by states in the Northeast to erect an infrastructure to support biodiesel use.

On July 11, 2002, the City of Keene accepted a grant of $2,500 from the Governor's Office of Energy.[122] Since then, Keene uses a blend of B20 fuel in approximately forty % of its 138-vehicle fleet,[123] and it has been using approximately 50,000 gallons of biodiesel fuel per year.[124] Since Keene began using the cleaner burning

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[119] Press Release. "First Biodiesel Station Opens in New Hampshire." PRWeb, the Free Wire Service. December 4, 2003 <http://www.prweb.com/releases/2003/12/prweb92401.htm> July 27, 2004.
[120] Recht, Mike. "Biodiesel Gains Another Foothold in New Hampshire." Nashua Telegraph.com. April 2, 2004.
[121] Press Release. "Rymes Oil Establishes First Bulk Terminal and Distribution System for Biodiesel in NH." New Hampshire Department of Environmental Services. April 2, 2004 <http://www.des.state.nh.us/press/press040204.htm> July 27, 2003.
[122] City of Keene, NH. Finance, Organization and Personnel Committee Meeting Minutes. July 11, 2002 <http://www.ci.keene.nh.us/minutes/fop/2002_07_11_fop_minutes.htm> July 27, 2004.
[123] "City of Keene Receives Grant to use Biodiesel Fuel," New Hampshire Pollution Prevention Program Wastelines, Summer/Fall 2002.
[124] Recht, Mike, "Biodiesel Gains Another Foothold in New Hampshire," Nashua Telegraph.com. April 2, 2004.

fuel, it has seen a reduction of greenhouse gases of 420 tons per year.[125] Keene is the first community in New Hampshire to use biodiesel. Keene State College is also the first institution of higher education in New Hampshire to use biodiesel.[126] During the summer months, Keene State will use B100, and in October, they will switch to B20 in order to keep the fuel from gelling in cold weather. To help alleviate the higher costs of using biodiesel, the Governor's Office of Energy and Community Services has provided funding.

Another first for New Hampshire is the Mount Cranmore biodiesel project. Cranmore Mountain Resort has become the first resort in the Northeast to use biodiesel in its snow grooming machinery.[127] This project started through a collaborative effort among the Resort, the New Hampshire Department of Environmental Services and the Granite State Clean Cities Coalition. In order for this project to be economically feasible, $40,000 per year is available through the Petroleum Violation Escrow Fund.[128] This money covered the cost of the biodiesel fuel tank and the incremental costs associated with using the fuel.

Vermont

Vermont is a relative newcomer in its interest in and use of biodiesel. During the 2003/2004 session of the state legislature, four bills were introduced promoting the use of biodiesel and other alternative fuels.[129] Two bills were introduced in order to exempt B20 from the diesel fuel tax, and one of these two (if enacted) would require the state to use biodiesel blends in heating oil. A third bill introduced into the legislature would increase the gasoline tax by one cent, as well as reduce the tax on biodiesel blends greater than B20 by four cents. The fourth bill, if passed, would completely remove particular

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[125] Varney, Robert, "New Hampshire Communities Providing Leadership on Energy Efficiency and Clean Energy," Region 1: New England, United States Environmental Protection Agency, February 10, 2004, http://www.epa.gov/region1/ra/column/archive/energy_20040210.html, July 29, 2004.
[126] Martin, Carolyn, "Fuel from Vegetable Oil: Biodiesel," New Hampshire Sentinel Source, July 29, 2002.
[127] Press Release, "NH Cranmore Mountain Resort First Resort in the East to use Biodiesel to Power Snow Grooming Machines," February 27, 2004.
[128] Air Resources, "Cranmore Mountain Resort Biodiesel Project," New Hampshire Department of Environmental Services, http://www.des.state.nh.us/ard/cranmore, July 27, 2004.
[129] The State of Vermont Legislature, http://www.leg.state.vt.us/, August 3, 2004.

biodiesel fuels from the definition of gasoline, most likely exempting biodiesel blends from the gasoline fuel tax.

Biodiesel has been gaining a foothold with towns throughout Vermont. The Guilford Central School's fleet of buses may become another fleet fueled with biodiesel fuel.[130] An August, 2004 vote decides whether the fleet will begin using B20 in its four-bus fleet for the upcoming school year. Guilford found that the use of biodiesel would add twenty cents per gallon to the cost of fueling the buses; however, the extra cost is intended to be offset with public fundraising.

The University of Vermont (UVM) has pushed vigorously to promote the use of biodiesel in Vermont. In 2001, a UVM student proposed testing the use of B20 with the Campus Area Transportation Service (CATS) buses.[131] They ran an eleven-year old bus on B20, and determined that this bus performed well enough to extend B20 to fuel the entire fleet of CATS buses. For the 2002 fall semester, all seven campus buses use B20. A computer model, determined that if all the existing buses in the CATS' fleet used B20, emissions would be reduced by approximately 3.2%. The student reaction to using this alternative fuel has been strongly positive.

Maine

In 2003, Maine introduced legislation to recognize biodiesel with a statute legally defining this fuel[132] and a bill, sponsored by Representative John Eder that would exempt biodiesel blends from the special fuel tax.[133] On May 18, 2004, Governor Baldacci signed into law a bill that provides a tax credit for biodiesel fuel producers.[134]

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[130] Mason, Justin. "Biodiesel is Gaining Favor with Other Local Users," Brattleboro Reformer, July 28, 2004.

[131] Parking and Transportation Services. "Biodiesel Buses Project," University of Vermont. August 3, 2004, http://www.uvm.edu/~bdiesel, August 5, 2004

[132] Maine State Legislature, "Title 36: Taxation, Part 5 Motor Fuel Tax, Chapter 459 Special Fuel Tax Act §3202. Definitions," November 9, 2003, http://janus.state.me.us/legis/statutes/36/title36sec3202.html, August 13, 2004.

[133] State of Maine Legislature, "LD 387: An Act to Exempt Biodiesel from the Special Fuel Tax," http://janus.state.me.us/legis/LawMakerWeb/billtextsearch.asp, August 12, 2004.

[134] "Tax Credits to Encourage Biodiesel," The House Democrats, May 18, 2004, http://www.maine.gov/tools/whatsnew/index.php?topic=HouseDems+News&id=2400&v=Article, August 12, 2004.

Governor Baldacci decided to increase the state's use of biodiesel for heating purposes in selected state buildings throughout Augusta.[135] During the 2004/2005 winter, Maine will purchase 360,000 gallons of B10, which outpaces the previous year's purchase of 27,000 gallons of B20. In 2003, the state buildings using B20 consisted of the Blaine House, the State Planning Office, and the Department of Motor Vehicles. The State House, Cross State Office Building, and the State Museum (among a host of others) will be utilizing B20 for heating purposes during the 2005/2005 winter. The Maine Department of Transportation implemented a pilot project in June 2003, consisting of ordering 2,500 gallons of B20 for transportation and space heating purposes for its fleet of trucks in Freeport.[136]

Connecticut

Connecticut's passing of the Clean Cars Bill (PA 04-84), modeled after California emissions standards, some of the strictest globally, allow for biodiesel to be utilized to clean up Connecticut's air. In May 2004, the LEV II or the Low-Emissions Vehicle II program, created in California and adopted by New York and Massachusetts, and approved by Governor Rowland, comes into force as early as 2007 with the new emissions standards. A Department of Energy study completed at UC Davis found that biodiesel use could reduce the risk of exhaust-related cancer significantly, though further tests are being completed to verify more specifically the extent of these findings.[137] The recently adapted emissions regulations demonstrate that cleaner air is a priority for Connecticut, and as such, the institution of less-polluting, alternative fuels, including biodiesel, is necessary.

The Connecticut General Assembly passed legislation to reduce greenhouse emissions in the state. According to PA 04-252, harmful gases must be reduced to year 1990 levels by January 1, 2010 and 10% below year 1990 levels by January 1, 2020. The Department of Environmental Protection is required to monitor greenhouse emissions and

[135] "Governor Significantly Increases State's Biodiesel Purchase," Maine Government News, August 5, 2004, http://www.maine.gov/tools/whatsnew/index.php?topic=Portal+News&id=2999&v=article-2004, August 12, 2004.
[136] Energy Advisors, LLC, Maine Energy Policy: Overview and Opportunities for Improvement, December 3, 2003, http://www.state.me.us/spo/energy/energycouncil/docs/EnergyReportText.pdf, August 12, 2004.
[137] "Chemical and Bioassay Analyses of Diesel and Particulate Matter—Summary," Department of Environmental Toxicology, UC Davis, http://journeytoforever.org/biofuel_library/UCDavisSumm.html.

establish a regional greenhouse gas registry and reporting system, and provide a state-wide inventory every three years.

The Connecticut General Assembly is reviewing a bill that would define biodiesel as a Class II renewable energy source. Connecticut defines two classifications for renewable fuels. Class I includes solar, wind, new sustainable biomass, landfill gas, and fuel cells, while Class II includes waste-to-energy facilities, biomass facilities not included in Class I, as well as certain approved hydro facilities.[138] The co-sponsors, Representatives Lawrence G. Miller of the 122nd district and Senator Bill Finch of the 22nd district, introduced the bill (HB No. 5424) to the General Assembly on February 20, 2004, at which time it was referred to the Joint Committee on Energy and Technology. If passed, the bill would establish a formal definition of biodiesel for the State of Connecticut and could open the door for passage of future acts relating to the fuel. As such, it stands as an important legislative stepping stone. However, relegating biodiesel fuel to a lower class of renewable energy sources, comparable with the energy recovery practices of burning municipal waste, could ultimately prove counterproductive in furthering widespread use of the fuel.

Consumer Education

One of the largest underlying factors behind the limited expansion of biodiesel throughout the United States and Connecticut is the lack of consumer awareness. Until business officials, legislators, and private citizens become increasingly aware of the environmental and public health threats posed by a continual reliance upon fossil fuels to meet energy needs, little will be done to increase the use of sustainable and environmentally-friendly alternatives, such as biodiesel. Government incentives, in the form of tax credits and perhaps subsidies, can make biodiesel affordable and accessible to a larger group of consumers, allowing the industry to step towards gaining a larger market. As concluded in a cost analysis study of several alternative fuels completed by the University of Georgia, "biodiesel represents one of the best alternatives as a renewable fuel for diesel engines for economic, energy, and environmental protection

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[138] "North American Renewables Markets," CO2e. http://www.co2e.com/CarbonBriefing/carbonbriefingview.asp?categoryid=10144.

perspectives."[139] However, until its presence becomes more widely known throughout Connecticut and the United States as a whole, biodiesel, as a large scale alternative fuel option, will remain underdeveloped indefinitely.

[139] "A Comprehensive Cost Analysis Study of Biodiesel, Compressed Natural Gas, Methanol, and Diesel for Bus Transit Systems," University of Georgia, http://www.biodiesel.org/resources/reportsdatabase/reports/tra/19940101_tra-030.pdf. pp 19.

Technical Appendix TA

Forecasting Methodology

In order to forecast values of the components listed in this analysis a variety of methods were used. CCEA obtained weekly data from the New Jersey Department of the Treasury[140] and Moore Research Center, Inc.[141] New Jersey's fuel prices are traditionally and significantly lower than prices in Connecticut, however we assume the premium cost of B20 over petro diesel should remain constant across states.

Using standard OLS regression analysis, we estimate a model for the price of B20 that we use to forecast its price. Because the price of B20 is a 20% mix of methyl ester and 80% diesel, we included the price of crude oil per gallon and the price of soy oil per gallon as independent variables. After running tests for co-integration and autocorrelation we found that each series was first-difference stationary and form the appropriate model listed below:

$$\Delta B20gal = \beta_1 \Delta crudeoilgal + \beta_2 \Delta soyoilgal + \mu$$

where:

ΔB20gal = first-difference of price of B20 per gallon

Δcrudeoilgal = first-difference of price of crude oil per gallon

Δsoyoilgal = first-difference of price of soy oil per gallon

Table TA1 lists regression results and shows that changes in the price of soy oil and crude oil per gallon are highly significant at the 1% level. These results imply that if crude oil increases \$1 per gallon other things equal, B20 would increase by 57 cents per gallon. If soy oil increased by \$1 per gallon other things equal, B20 would increase by 22.7 cents per gallon.

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[140] http://www.state.nj.us/cgi-bin/treasury/purchase/fuel/fuelsearch.pl?fueltype=biodiesel

[141] http://www.mrci.com/ohlc/ohlc-06.asp

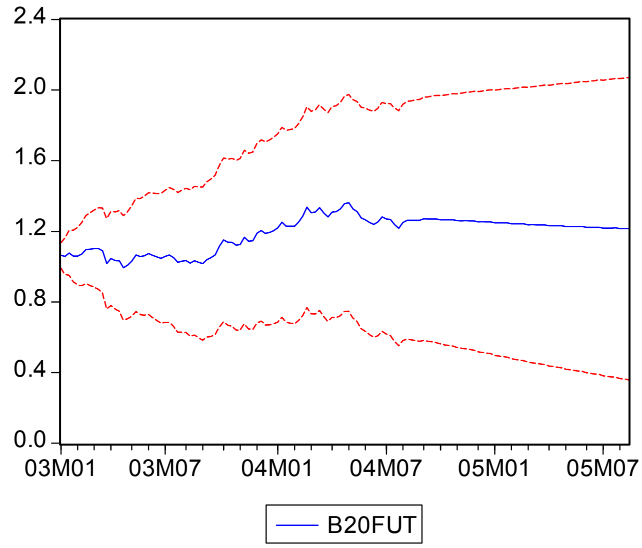
Table TA1: Dependent Variable: D(B20 Gal)
Method: Least Squares
Sample (adjusted): 1/07/2003 8/10/2004
Included observations: 84 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(Crude Oil Gal)	0.571834	0.126868	4.507300	0.0000
D(Soy Oil Gal)	0.227033	0.055796	4.068950	0.0001

R-squared	0.268297	Mean dependent var	0.003310
Adjusted R-squared	0.259374	S.D. dependent var	0.042155
S.E. of regression	0.036279	Akaike info criterion	-3.771653
Sum squared resid	0.107924	Schwarz criterion	-3.713777
Log likelihood	160.4094	Durbin-Watson stat	2.154434

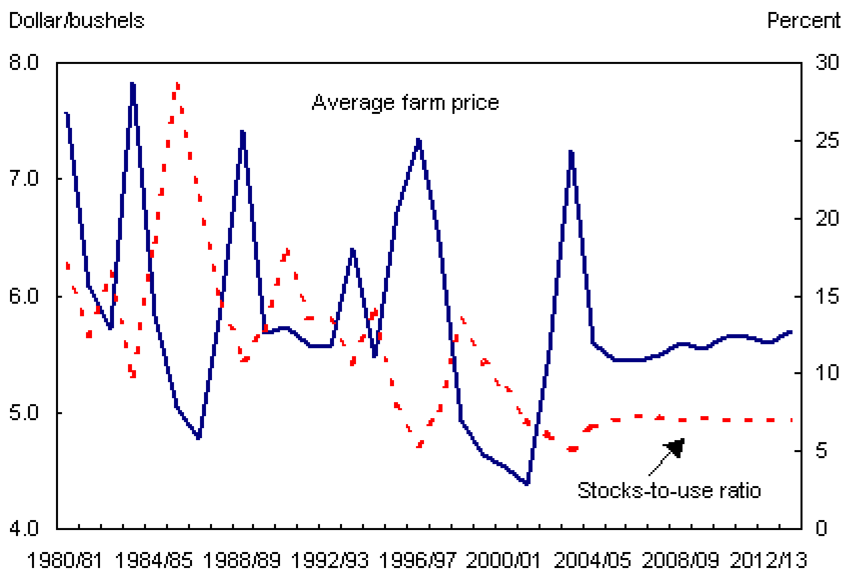
In order to project the future price of B20, we forecast both soy oil and crude oil price per gallon. Soy bean prices were held constant into the future, consistent with a report published by the USDA suggesting the future stabilization of soybean prices.[142] The future price of crude oil was projected using weekly averaged spot prices up to the week of August 10, 2004, and then using crude oil futures beyond that date provided by NYMEX that were actually decreasing. This assumes that the current futures prices reflect the true future price of crude oil. The B20 premium would remain unaffected by fluctuations in the price of oil, which serves as the basis for our cost analysis. Therefore, changes in spot and futures prices will influence the price of B20, but not the premium of B20 over petro diesel. Under these assumptions, the following forecast shows a slight decrease in the future price of B20.

[142] http://www.ers.usda.gov/Briefing/SoybeansOilcrops/2004baseline.htm



Forecast: B20FUT	
Actual: B20	
Forecast sample: 12/31/2002 8/16/2005	
Adjusted sample: 12/31/2002 8/16/2005	
Included observations: 84	
Root Mean Squared Error	0.073807
Mean Absolute Error	0.059582
Mean Abs. Percent Error	5.420160
Theil Inequality Coefficient	0.031906
Bias Proportion	0.035775
Variance Proportion	0.214574
Covariance Proportion	0.749650

Soybean prices projected to stabilize after 2004/05



Source: USDA Agricultural Baseline Projections to 2013, February 2004.
Economic Research Service, USDA.