BAY AREA AIR QUALITY MANAGEMENT DISTRICT
PROFESSIONAL SERVICES CONTRACT
CONTRACT NO. 2003-004

"Many people have falsely assumed that you have to choose between protecting the environment and protecting the economy. Nothing could be further from the truth."
Gov. Arnold Schwarzenegger

BIODIESEL FEASIBILITY STUDY FOR THE BAY AREA AND CONDUCT A BIODIESEL PILOT PROJECT
FINAL REPORT - SEPTEMBER 27, 2005

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Introduction

The use of vegetable oils for use as a fuel in diesel engines is not new. In 1900 the inventor of the diesel engine, Dr. Rudolf Diesel, exhibited his new invention at the Paris World's Fair. His concept was that this revolutionary new source of power would be fueled by vegetable oils grown by Europe's farmers and that it would become the primary source of power in the new century. Unfortunately for us, only part of his vision became true. The diesel engine has become the power source of choice for commercial trucking, railroads and ships, but the fuel of choice is petroleum diesel not vegetable oil.

Our global economy now relies upon petroleum for fuel which pollutes the environment, diminishes human health, creates global conflicts and is being depleted at an alarming rate. Global demand for petroleum has exceeded the discovery of new reserves for the first time this year. Given the tragic nature of recent events we are now painfully aware that our petroleum supplies are subject to disruption by hurricanes and global conflicts.

Biodiesel has the potential to become the New Oil. It is nontoxic, biodegradable and made from renewable resources that reduce green house gases. The feedstocks that are used to make it can be grown and harvested in a socially responsible manner that respects the environment and supports economic development, even in some of the most impoverished parts of the world. Our challenge is to make this transition now before the growing global demand for energy has catastrophic political and environmental effects.

The contract for this study was awarded to Biodiesel Industries on April 10, 2003, with a final contract signed between the parties on July 2, 2003. The objectives for this study were:

1. Develop, implement and operate a biodiesel pilot project located in the DISTRICT that uses local feedstocks to produce Biodiesel.

2. Distribute the pilot project Biodiesel to local fleets.

3. Compare air emissions resulting from the use of the pilot project Biodiesel to air emissions from using petroleum diesel in local fleets.

4. Deliver report describing the three objectives above as well as obstacles to expanding biodiesel production in the District and actions required to remove the obstacles.

Executive Summary

Imagine if you can that Dr. Diesel's prediction that his new engine would be run on vegetable oil derived fuels became true and that all diesel engines have been running on biodiesel for the past one hundred years. The air is clean and there is an abundance of biodiesel made from resources grown by California farmers. Imagine also that petroleum was just recently discovered in the Middle East and that petroleum proponents are asking to have their new fuel approved for use in California. Their argument would be that even though using their product will result in severe environmental threats during the extraction, production and transport of their product, and that using their product as a fuel will produce toxic and carcinogenic emissions along with substantial increases in hydrocarbons, carbon monoxide and particulate matter, all with proven deleterious effects to human health, and that their product will come from politically unstable parts of the world administered by regimes that are hostile to us, but there is a bright side. Their product has been proven, by a series of studies with protocols under debate, to have a slight decrease in NOx emissions with an impact on ozone that is being questioned. Would petroleum diesel be permitted to be used as a fuel in California under such circumstances?

Unfortunately Dr. Diesel's prediction did not come true. Biodiesel is trying to become accepted in California with the primary concern expressed by regulators that there will be an increase in NOx. This study shows that biodiesel has substantial emission benefits under a range of testing protocols and there are NOx reduction strategies that work with biodiesel. Recently there has been an indication from CARB that biodiesel may have a role to play in California's fuel portfolio as a means to help meet recently adopted greenhouse gas reduction targets.

Another impediment to biodiesel implementation in California has historically been its high price in comparison to petroleum diesel. Recent price increases in petroleum coupled with biodiesel subsidies in the 2005 Energy Bill have made biodiesel competitively priced with petroleum diesel. It is now possible to make competitively priced biodiesel from a range of feedstocks available in the Bay Area and surrounding counties.

Scope of Work

The contract for this project specified a scope of work which was to be followed by the contractor. As this work was pursued there were several changes made in consultation with BAAQMD personnel. The scope of work was defined in the contract as follows:

> CONTRACTOR shall perform each of the tasks listed in Section B, pages 6 and 7 of the proposal, with additional specificity and detail provided below.
>
> 1. Construct or relocate a Biodiesel production facility in the DISTRICT and produce at least 5,000 gallons of 100% (B100) Biodiesel fuel from local feedstocks produced, recovered and recycled in the DISTRICT.
>
> 2. Analyze and evaluate no less than 20 local feedstocks and the Biodiesel produced from the local feedstocks. Selection of local feedstocks to be used in the pilot project shall be preapproved by the DISTRICT and shall include at a minimum, oils and fats from restaurants, rendering plants, dairies and agriculture.
>
> 3. Quantify and describe the fate of the feedtock prior to the implementation of the pilot project and volume of Biodiesel produced after implementation of the project, including any new waste streams and by-products created from the conversion process.
>
> 4. Describe the processing and conversion of the feedstock to Biodiesel and distribution into the fleet.
>
> 5. Identify the standards to which the biodiesel will be produced and describe any additives required to avoid problems with the use of Biodiesel.
>
> 6. Distribute a blend of 2% (B2), 5% (B5), 20% (B20), and 100% (B100) Biodiesel to petroleum diesel in no less than two heavy-duty fleet types. Possible fleet types include garbage trucks, school buses, transit buses, shuttles and agricultural equipment. At a minimum, CONTRACTOR, shall contact the fleet managers for the following entities to invite their participation in the pilot project: City of Palo Alto and Sonoma County solid waste hauling contractors, East Side Union High School District, Clos Du Bois and Benziger wineries, Clover Stornetts Farms, San Francisco MUNI and Petaluma Transit, Ecology Center, Albertson's, San Francisco International Airport Land Side Operation and Emery Go-Round Shuttle.
>
> 7. Provide appropriate guidance to fleet users for safe and efficient conversion from petroleum diesel to Biodiesel use.

8. Administer a DISTRICT-approved survey to the fleet operators that will provide a detailed description of the fleet of vehicles using the Biodiesel, average volume of diesel fuel use prior to the pilot project and after implementation of the pilot project, and their experience with the conversion of their fleet from petroleum diesel to a Biodiesel blend.

9. Test, analyze, evaluate and compare the air emissions resulting from the use of the four different pilot project blends with petroleum diesel. Proivde emission test data for NOx and PM for at least five representative vehicles from each of the two selected test fleets from item 6 above.

10. Analyze the cost of implementing the pilot project, including permitting and regulatory costs, developing infrastructure for the conversion of feedstocks to Biodiesel, disbursing the fuel, retrofit of vehicles, period of cost recovery and any other costs associated with developing the project.

11. Provide a quantitative comparison of the "cradle-to-grave" environmental impacts of the Biodiesel project with a no-project case.

12. Submit to DISTRICT a Report responding to the Scope of Work items 1 through 11 above.

Report of Results

The structure of reporting the results of this study will be to present each task as listed in the Scope of Work and then describe the work performed with the results.

Task 1 – Biodiesel Production Facility

1. Construct or relocate a biodiesel production facility in the DISTRICT and produce at least 5,000 gallons of 100% (B100) Biodiesel fuel from local feedstocks produced, recovered and recycled in the DISTRICT.

To complete this project CONTRACTOR used a Mini MPU (1/10 scale Modular Production Unit) that was fabricated in Bakersfield, California for the US Navy and was placed on loan for this project at the Ecology Center in Berkeley, California. The Mini MPU was designed to be deployable. All components fit onto a trailer towed by a ¾ ton pick up truck. The Mini MPU was connected by a single electrical cord which provided all power for electrical motors and process heat.

The Mini MPU was capable of processing 150 gallons of feedstock per batch from a wide variety of sources and was designed to duplicate all process phases used in full scale Modular Production Units (see Insert #2). The electrical system was explosion proof for use with alcohol vapors in the event of accidental spills and had a remotely mounted control panel with emergency stops both on the reactor and on the control panel. The reactor and other process components were mounted in a steel containment sump that wss designed to hold 250% of the largest vessel. All major reaction and filtering components were fabricated in stainless steel. A centrifuge was utilized to optimize separation of heavy phase liquids (such as glycerol and water) from light phase liquids (such as Biodiesel). All electrical components (including motors, pumps, heaters, control panels and wiring) as well as tanks, piping and valves were fabricated to UL standards. A special filtering and drying system was incorporated into the system to meet ASTM standards. Vents were adapted to a vacuum system and large activated charcoal canisters to control VOC emissions. Fire safety equipment, absorbent pads, and personal safety equipment (gloves, goggles, face masks, respirators and aprons) were provided for the operators. A field laboratory was set up for testing feedstocks as they came in as well as for monitoring the status of each step in the reaction process. Final products were tested at the Naval Tech Center at Naval Base Ventura County or at Biodiesel Industries laboratory in Denton, Texas. Processing was conducted at the Ecology Center in

Berkeley, California for several months, and after that at the Naval Tech Center when the Mini MPU was relocated there.

A specially fabricated truck was used to pick up used cooking oils from area restaurants (see Insert #1). The truck was an Izusu diesel (run on B100) that had a 600 gallon heated tank for holding the waste cooking oil.

Several public outreach events were conducted while the Mini MPU was located at the Ecology Center, including tours conducted for the East Bay Municipal Utility District, television stations, UC Berkeley's Combustion Analysis Laboratory, Bay Area Air Quality Management District and private venture capital firms.

Insert #1 – Grease Collection System Photos


RESERVED

Insert #2 – Mini Modular Biodiesel Production Unit Photos

Task 2 – Feedstock Evaluation

2. Analyze and evaluate no less than 20 local feedstocks and the Biodiesel produced from the local feedstocks. Selection of local feedstocks to be used in the pilot project shall be preapproved by the DISTRICT and shall include at a minimum, oils and fats from restaurants, rendering plants, dairies and agriculture.

Biodiesel can be produced commercially from a variety of oils and fats:

- Animal fats: all the other variations of tallow, lard, hog fat, poultry fat and fish oils
- Vegetable oils: soy, corn, canola, sunflower, rapeseed, cottonseed, mustard, palm, coconut, peanut, olive, sesame, and safflower
- Recycled greases: used cooking oils, restaurant frying oils, grease trap materials, waste water treatment plant scum
- In the future: oils produced from algae, fungi, bacteria, molds, and yeast.

Chelsea Teall titrating feedstock samples from waste water treatment plant

The feedstocks which were collected and used for biodiesel feedstocks include:

A. Restaurant yellow grease from:
   Spengers Seafood Restaurant in Berkeley
   Pyramid Brewery in Berkeley
   CAL student housing cafeterias
   Mel's Diner
   Berkeley Marina hotels and restaurants (3)
   Stanford student housing cafeterias
   San Jose restaurants (4)
   San Jose Waste Water Treatment Plant

B. Renedering Companies:
   Baker Commodities
   National By-Products

C. No suitable dairy by-products were found. All samples were high in water, protein, and other unsaponifiables, and low in reactable triglycerides. As pat of this investigation it was found that many of the coproducts of biodiesel oil seed extraction and biodiesel production may be used to supplement cattle feed. Both the meal of many oil seeds and glycerin may be used in such a manner.

D. Agriculture Products:
   Almond
   Apricot
   Beef Tallow
   Canola
   Castor
   Chicken Fat
   Cotton
   Fish Oil
   Grape
   Hog Fat
   Jatropha
   Mustard (2)
   Neem
   Pongamia
   Soy – crude & refined

Jatropha nursery in India

The suitability of each oil and fat was determined by first removing any excess water or particulates, then measuring the free fatty acid level. An appropriate formulation for the transesterification reaction was developed and small samples were reacted then tested. All samples were found to be capable of being transformed into biodiesel. The principal difference between the feedstocks was cost. Lower free fatty acid feedstocks that are edible tend to be higher in price, while higher free fatty acid inedible feedstocks tend to be lower in price. Couple this with the varied subsidy support which different feedstocks attract, and it becomes a complex calculus for the biodiesel producer to determine which feedstock is best for use at any particular time. Virgin agricultural products generally receive twice the amount of subsidy support as compared to recycled agricultural products under both the USDA Bioenergy Program, and the IRS Blenders Tax Credit. Although this result may seem counter intuitive to recycling advocates, it is a testimony to the lobbying power of the American farmer.

The complexity of choosing the right feedstock is important to the profitability of a biodiesel production facility. As an example (and these are somewhat arbitrary figures to illustrate a point), if soybean oil costs $2.50 per gallon delivered, has a subsidy value of $1.75, a processing cost of $.50, and a processing time of 8 hours, then the net cost would be $1.25, excluding capitalization and overhead. With a sales price of $2.25 for finished biodiesel and an annual capacity of 3,000,000 gallons, the plant would generate $3,000,000 in gross profits.

Compare this to a "free feedstock" such as waste water treatment scum which has a cost of $.00 per gallon delivered, a subsidy value of $.87, a processing cost of $1, and a processing time of 24 hours. The net cost of production would be $.13 per gallon, so with a sales price of $2.25 the gross profit per gallon would be $2.12. Consider though that the same production facility would only be able to produce 1,000,000 gallons per year, with a resulting gross profit of $2,120,00. The conclusion then is that the waste water treatment scum would not be the best feedstock to use for optimizing profits under this scenario even though it is free.

The cultivation and harvesting of biodiesel feedstocks can have unexpected beneficial effects. The canola which was used in these tests was grown on test plots in the Central Valley where it was being used as part of a bioremediation project to remove excessive levels of selenium in the soil. The harvesting of castor beans can also be used to control an otherwise noxious invasive exotic species. Jatropha curcas is also being considered as a potential feedstock because it can be grown on non-irrigated waste land.

Insert #3 – Harvesting Castor Beans

Insert #4 – Field Testing Lab at Ecology Center

Task 3 – Feedstock Utilization

3. Quantify and describe the fate of the feedtock prior to the implementation of the pilot project and volume of biodiesel produced after implementation of the project, including any new waste streams and by-products created from the conversion process.

Restaurant fryer oil is collected by several companies for a fee to the restaurants and the primary market for the collected oil is in the animal feed market. The fryer oil is also collected on an ad hoc basis by small underground biodiesel producers that are neither permitted to collect or properly zoned for production. As the price of diesel fuel continues to rise there will be a greater incentive for biodiesel home brewers to collect used fryer oil from area restaurants, which could impact the availability of that feedstock for commercial production. Several accidents as a result of home brewing biodiesel were reported during the course of the study, including explosions of methanol vapors and the destruction of a garage and home by fire.

A substantial opportunity exists for cultivating non-irrigated farmland which is not currently being used to grow commercial crops. Several species of oil bearing seeds can be grown in Bay Area and surrounding counties. Work was undertaken to grow mustard, canola and jatropha and the results are still being evaluated. It was found that canola and mustard could be grown successfully on non-irrigated acreage and that the resulting oil was suitable for making biodiesel. An extrusion/expeller style system was used and the resulting crude oils were converted to biodiesel. At present there are hundreds of thousands of acres in Northern California that could be placed into production, with the resulting oils being used to generated biodiesel.

There were also several tests run

on extruding cottonseed, castor and “pumice” (grape skins and seeds left over from the wine crush). The problem with all of these materials is that there is little or no value to the meal. Traditional oil seeds such as soybeans or canola have a very high meal value, which coupled with the value of the oil, contributes to the “crush cost” and makes the entire enterprise economically viable. The Chicago Board of Trade maintains an “Agricultural Calculator” on its web site which is helpful in understanding the dynamic between meal and oil. Suffice it to say that extensive work still needs to be done to find uses for the meal portion of many biodiesel feedstocks which have been proposed.

Task 4 – Biodiesel Processing & Distribution

4. Describe the processing and conversion of the feedstock to Biodiesel and distribution into the fleet.

Compared to the chemistry of diesel fuel, which contains hundreds of compounds, the chemistry of different fats and oils typically used for biodiesel are very similar. Each fat or oil molecule is made up of a glycerin backbone of three carbons, and on each of these carbons is attached a long chain fatty acid. These long chain fatty acids are what react with methanol to make the methyl ester, or biodiesel. The glycerin backbone is turned into glycerin and sold as a byproduct of biodiesel manufacturing. The fats and oils listed above contain 10 common types of fatty acids which have between 12 and 22 carbons, with over 90% of them being between 16 and 18 carbons. Some of these fatty acid chains are saturated, while others are monounsaturated and others are polyunsaturated. Within the limits of the specifications, the differing levels of saturation can affect some of the biodiesel fuel properties.


Test Tube batches using waste fryer oil and various formulations, middle is "just right"

Biodiesel was produced using a widely described and utilized formulation of using two base reactions of the feedstock with methanol and sodium hydroxide. The reactants are mixed, and the glycerol compounds are removed by decanting between reactions. The lighter portion of the separated liquid is then washed with water (to remove excess glycerin, methanol, soaps, and other water soluables), and a mild water acid solution to neutralize any excess sodium hydroxide. The liquid is then dried to remove excess water, filtered to remove particulates, and tested to assure conformance with ASTM 6751 (the recognized standard for biodiesel in the US).

The chemical nature of biodiesel allows it to be blended with any kind of distillate, or diesel fuel. This includes light fuels such as jet fuel, kerosene, No.1 diesel, or military fuels (JP8, JP5), as well as normal diesel fuel like No. 2 diesel for diesel engines or gas turbines, and heating oil for boilers or home heating. Once biodiesel is blended thoroughly with diesel fuel, it stays together as one fuel and does not separate over time (assuming the fuel is maintained at temperatures above its cloud point). Once blended, B20 and lower blends should be treated exactly like conventional petrodiesel.

More recently, as demand increases, petroleum terminals and pipeline racks are installing biodiesel blending capability so that jobbers and distributors can receive a biodiesel blend directly at the rack and store and distribute only the blended biodiesel. This finished blend can then be sold to fleet or other applications that have some type of on-site storage. Even more recently, there are an increasing number of public pumps and key card pumps that are carrying biodiesel blends for individual users or fleets who do not have their own on-site storage capability (see Appendix D).

Insert 5 – Expeller/Extrusion Facility Photos

Red Rock Ranch 8/12/05
Testing the new oil seed
processing equipment

Task 5 – Biodiesel Standards & Additives

5. Identify the standards to which the biodiesel will be produced and describe any additives required to avoid problems with the use of Biodiesel.

ASTM International is a consensus based standards group comprised of engine and fuel injection equipment companies, fuel producers, and fuel users whose standards are recognized in the United States by most government entities, including states with the responsibility of insuring fuel quality. The specification for biodiesel (B100) is ASTM D6751. This specification is intended to insure the quality of biodiesel to be used as a blend stock at 20% and lower blend levels. Any biodiesel used in the United States for blending should meet ASTM D6751 standards.

Biodiesel is a legally registered fuel and fuel additive with the U.S. Environmental Protection Agency (EPA). The EPA registration includes all biodiesel meeting the ASTM International biodiesel specification, ASTM D 6751, and is not dependent upon the oil or fat used to produce the biodiesel or the specific process employed.

ASTM 6751 is the standard for Biodiesel in the US. The standard is as follows and compares to ASTM D975 for #2 petroleum diesel. Quality control is a major concern. BQ 9000 recognizes the "Big 5" as being the standard for commercial production. A field test kit has been developed by Randall Von Wedell of Cytoculture in Point Richmond, CA

As with other ASTM fuel standards, ASTM D6751 is based on the physical and chemical properties needed for safe and satisfactory diesel engine operation. It is not based on the specific raw materials or the manufacturing process used to produce the biodiesel. The finished blend stock must meet the properties specified in Insert #5 below as well as the following definition:

“Biodiesel, noun, a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100.”

Insert #6 – ASTM Standard for Biodiesel

Requirements for Biodiesel (B100) Blend Stock as Listed in ASTM D6751-03

Property ASTM Limits Units Method

Flash Point	D93	130.0 min. °C
Water and Sediment	D2709	0.050 max. % vol.
Kinematic Viscosity, 40°C	D445	1.9 - 6.0 mm^2/s
Sulfated Ash	D874	0.020 max. % mass
Sulfur *	D5453	0.0015 max. (S15) % mass
0.05 max. (S500)		
Copper Strip Corrosion	D130	No. 3 max.
Cetane Number	D613	47 min.
Cloud Point Carbon	D2500	Report to Customer °C 0.050 max. %
Residue**	D4530	mass
Acid Number	D664	0.80 max. mg KOH/g
Free Glycerin	D6584	0.020 max. % mass
Total Glycerin	D6584	0.240 max. % mass
Phosphorus Content	D4951	0.001 max. % max.
360 max. °C		

Distillation Temperature, 90% D1160 Recovered (T90)***

* Sulfur content of on-road diesel fuel to be lowered to 15 ppm in 2006 ** Carbon residue shall be run on the 100% sample *** Atmospheric equivalent temperature

The definition of biodiesel contained in ASTM D 6751, along with the physical and chemical property limits, eliminates certain “biofuels” that have been incorrectly called biodiesel in the past. The raw vegetable oil or animal fat feedstock, partially reacted oils are not biodiesel and should not be confused as being biodiesel.

Raw or refined vegetable oil, or recycled greases that have not been processed into biodiesel, are not biodiesel and should be avoided. Research shows that vegetable oil or greases used in CI engines at levels as low as 10% to 20%, can cause long-term engine deposits, ring sticking, lube oil gelling, and other maintenance problems and can reduce engine life.

Insert #7 – Biodiesel Compared to #2 Diesel

Selected Properties of Typical No. 2 Diesel and Biodiesel Fuels.

Fuel Property Diesel Biodiesel
Fuel Standard ASTM D975 ASTM D6751

Lower Heating Value, Btu/gal	~129,050	~118,170
Kinematic Viscosity, @ 40°C	1.3-4.1	4.0-6.0
Specific Gravity kg/l @ 60°F	0.85	0.88
Density, lb/gal @ 15°C	7.079	7.328
Water and Sediment, vol%	0.05 max	0.05 max
Carbon, wt %	87	77
Hydrogen, wt %	13	12
Oxygen, by dif. Wt % Sulfur, wt %*	0 0.05 max	11 0.0 to 0.0024
Boiling Point, °C	180 to 340	315 to 350
Flash Point, °C	60 to 80	100 to 170
Cloud Point, °C	-15 to 5	-3 to 12
Pour Point, °C	-35 to -15	-15 to 10
Cetane Number	40-55	48-65

Lubricity SLBOCLE, grams 2000-5000 >7,000
Lubricity HFRR, microns 300-600 <300
*Sulfur content for on-road fuel will be lowered to 15 ppm maximum in 2006

Currently there are ASTM specifications for B100 (D6751) and for petrodiesel (D975), but there is not a separate approved specification for biodiesel blends. Current practice to insure the quality of biodiesel blends is to use petrodiesel (No. 1 or No. 2) meeting D975 and biodiesel meeting D6751 prior to blending. Once blended, it is very difficult to determine the quality of the B100 used to make the blend. ASTM specifications for finished biodiesel blends up to B20 are under development, so please check with ASTM or the National Biodiesel Board (NBB) for updated information.

ADDITIVES - Additives are necessary for the control of stability, cold flow, microbial growth, water dispersion, and NOx reduction.

1. Stability - Few users have reported stability problems with B20 or B100 in the United States, but stability is a major issue for engine and fuel system manufacturers. Stability is a broad term, but really refers to two issues for fuels: long-term storage stability or aging and stability at elevated temperatures and/or pressures as the fuel is recirculated through an engine's fuel system. In the diesel fuel arena, long-term storage stability is commonly referred to as oxidative stability, and thermal stability is the common term for the stability of fuels at elevated fuel system temperatures. At this time there are no ASTM specifications for the stability of either diesel or biodiesel.

In biodiesel, fuel aging and oxidation can lead to high acid numbers, high viscosity, and the formation of gums and sediments that clog filters. If the acid number, viscosity, or sediment measurements exceed the limits in ASTM D6751, the B100 is degraded to the point where it is out of specification and should not be used. Biodiesel with high oxidation stability will take longer to reach an out of specification condition, while biodiesel with low oxidation stability will take less time in storage to reach an out of specification condition. Monitoring the acid number and viscosity of B100 over time can provide some idea about whether the fuel is oxidizing, with sampling at the receipt of the B100 and periodically during storage providing the most useful data.

There is not a lot of experience with B100 storage for periods greater than six months, so if the fuel is kept longer than six months, anti-oxidants should be used and/or periodic tests for acid number and sediments, and perhaps viscosity, should be performed to insure that the fuel remains within the boundaries of ASTM D6751.

As of this date there is a growing database available on B20 but more data is needed to accurately predict the impact of biodiesel on blend oxidative and thermal stability. Data includes results of the ASTM D4625 stability test for several B20 fuels. Compared to the B100 data on the same fuels, it appears that B20 may have a longer storage life than B100. Those data also show that some B20 can have good stability and others do not depending on the B100 used for blending. The D4625 data suggests that most B20 can be stored for 8 to 12 months. The National Biodiesel Board recommends that B20 be used within 6 months. This is comparable to the recommendations of petrodiesel suppliers, some of whom recommend petrodiesel be used within 3-4 months.

Adding antioxidants and/or stability additives is recommended for storage over longer periods.

Thermal stability is generally meant to be an indicator of fuel degradation when subjected to high temperatures for a short period of time, similar to what would be experienced in the fuel injector or fuel system of a modern diesel engine. If the fuel degrades here, the primary concern is the potential for injector coking. The data available regarding thermal stability generally show that B100 has good thermal stability. This makes some sense, as saturated vegetable oils and animal fats are used as frying oils and are subjected to extremely hot temperatures for relatively long periods of time. In addition, most reports from the field have indicated that biodiesel produces less injector coking that conventional diesel fuel, but much of this information is anecdotal.

In some cases, deposits from the cleaning effect or solvency of B100 have been confused with gums and sediments that could form over time in storage as the fuel ages. While sediment can clog a filter in either case, care should be taken to make sure the reason for the clogging is properly identified. For example, if the acid number of the fuel is within specification, then sediment formation is most likely due to the cleaning affect and not to fuel aging or oxidation.

2. Cold Flow - The cloud point of B100 starts at 30°F to 32°F for most of the vegetable oils that are made up primarily of mono- or poly-unsaturated fatty acid chains and can go as high as 80°F or higher for animal fats or frying oils that are highly saturated. Some examples of the cloud, pour, and cold filter plug point of B100 made from various sources can be found in Insert #8. It should be noted that the pour point of B100 is usually only a few degrees lower than the cloud point, so once biodiesel "begins to freeze," gelling can proceed rapidly if the temperature drops only a few degrees further.

Insert #8 - Cold Flow Data for Various B100 Fuels

Test Method	Cloud Point ASTM D2500		Pour Point ASTM D97		Cold Filter Plug Point ASTM D4539	
B100 Fuel	oF	oC	oF	oC	oF	oC
Soy Methyl Ester	36	2	30	-1	28	-2
Canola Methyl Ester	27	-3	25	-4	25	-4
Lard Methyl Ester	57	14	52	11	52	11
Edible Tallow Methyl Ester	68	20	55	13	57	14
Inedible Tallow Methyl Ester	73	23	46	8	50	10
Yellow Grease 1 Methyl Ester	108	42	54	12	52	11
Yellow Grease 2 Methyl Ester	46	8	46	8	34	1

3. MICROBIAL GROWTH - Biocides are recommended for conventional and biodiesel fuels wherever biological growth in the fuel has been a problem. If biological contamination is a problem, water contamination needs to be controlled with a water dipersant since the aerobic fungus, bacteria, and yeast hydrocarbon utilizing microorganisms (HUMBUGS) usually grow at the fuel-water interface. Anaerobic colonies, usually sulfur reducing, can be active in sediments on tank surfaces and cause corrosion. Since the biocides work where the HUMBUGS live (in the water), products that are used with diesel fuels will work equally well with biodiesel.

Task 6 – Distribute Biodiesel

6. *Distribute a blend of 2% (B2), 5% (B5), 20% (B20), and 100% (B100) Biodiesel to petroleum diesel in no less than two heavy-duty fleet types. Possible fleet types include garbage trucks, school buses, transit buses, shuttles and agricultural equipment. At a minimum, CONTRACTOR, shall contact the fleet managers for the following entities to invite their participation in the pilot project: City of Palo Alto and Sonoma County solid waste hauling contractors, East Side Union High School District, Clos Du Bois and Benziger wineries, Clover Stornetts Farms, San Francisco MUNI and Petaluma Transit, Ecology Center, Albertson's, San Francisco International Airport Land Side Operation and Emery Go-Round Shuttle.*

All listed fleets were contacted by Bob Brown at Western States Oil and the following fleets agreed to participate in the pilot project:

Benziger Winery, Glen Ellen, CA
Ecology Center, Berkeley, CA
Peninsula Sanitation Service, Palo Alto, CA
Rental Car Shuttle, Oakland, CA

Western States Oil blended the biodiesel provided by Biodiesel Industries with petroleum and an additive to make B20, which was then delivered to the fleet either by WSO or one of its sub distributors. In the case of Benziger the B20 was delivered by Royal Petroleum and in the case of the Rental Car Shuttle the B20 was delivered by Easy Fuel. Tailpipe emission testing was performed on a selection of vehicles in each fleet prior to the use of the B20. Testing was repeated once biodiesel use was initiated. Surveys were administered after biodiesel had been used by the fleets for some period of time. Because B20 is the most widely used blend of biodiesel and because of the need to test a larger number of vehicles than specified in order to get a more significant sampling, it was decided to limit the testing to B20 compared to petroleum diesel, but to do this in a larger number of vehicles than specified.

Biodiesel was also distributed by other sub-distributors of Western States Oil, but because of their wish to maintain the confidentiality of their client's identities, these distributors declined to participate. From confidential interviews with these and other distributors, it is estimated that about 3,000,000 gallons of biodiesel was distributed in the Bay Area this past year.

There are now also several biodiesel retail stations in the Bay Area, including locations in Berkeley, San Jose and Vallejo (see Appendix D). Updated information of biodiesel retail stations can be obtained at www.biodiesel.org.

There are several small biodiesel coops that are producing small amounts of biodiesel. The bulk of the biodiesel consumed in the Bay Area is produced outside of the area. There was a biodiesel production facility in Vallejo, but it has now shut down. There is a new 2.5 million gallon per year facility that is rumored to be opening late this year in Richmond. Several other groups are also investigating potential biodiesel plant locations in the Bay Area.

Task 7 – Educate Fleet Managers

7. Provide appropriate guidance to fleet users for safe and efficient conversion from petroleum diesel to Biodiesel use.

Each fleet manager was instructed in the use and implementation of biodiesel as set forth in the U.S. Department of Energy, National Renewable Energy Laboratory's publication Biodiesel Handling and Use Guidelines, available at http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/tp36182.pdf. The principal points that were emphasized were:

1. When the biodiesel is delivered retain a sample in a labeled container. This "retain" will provide a reference point if there are any problems later found with the fuel. This is common practice in the petroleum industry.
2. Examine the biodiesel for clarity. It should appear clear and bright. 10 point type should be readable through a pint jar at 70 degrees Fahrenheit. Cloudiness is an indication of pour fuel quality and/or moisture.
3. Obtain a Certificate of Analysis from the supplier indicating that the fuel meets ASTM 6751 standards.
4. Confirm with the supplier that proper additives for microbial growth, stability, water dispersion and cold flow have been added.
5. Have the storage tanks in which the Biodiesel is to be stored examined for water, particulate and microbial contamination prior to use. If there is a problem, it must be alleviated prior to storing biodiesel.
6. Keep an eye on vehicle fuel filters when first using Biodiesel. Filters may need changing after the first couple of tanks of biodiesel because the Biodiesel acts as a solvent to remove varnishes, gums and other contaminants that may be present in the vehicle fuel system.
7. Wipe any biodiesel spills on the vehicle off with soap and water. Biodiesel is a solvent and will discolor or even blister painted surfaces if allowed to sit for an extended period of time.

8. If the Biodiesel is to be stored for an extended period of time, have it tested every three months for its acid number. A rising acid number is an indication of deteriorating fuel quality.

9. Monitor rubber fuel lines and leaks. Some older materials may not be compatible with higher concentrations of Biodiesel. Fuel lines that become sticky and soft to the touch need to be replaced.

10. A test kit is now available for testing Biodiesel for commonly found problems in fuel which is off specification. The kit is not a substitute for full ASTM 6751 testing, but it is a good firewall for preventing problems with off spec biodiesel in the field.

Task 8 – Fleet Survey

8. Administer a DISTRICT-approved survey to the fleet operators that will provide a detailed description of the fleet of vehicles using the Biodiesel, average volume of diesel fuel use prior to the pilot project and after implementation of the pilot project, and their experience with the conversion of their fleet from petroleum diesel to a Biodiesel blend.

The survey results for the following fleets are contained in Appendix B and summarized below:

Benziger Family Winery

1883 London Ranch Road
Glen Ellen, CA 95442
Contact: Matt Atkinson 707-486-3906
Vehicle #1: 1987 Massey-Ferguson 375 4WD, Perkins LD 31140, VIN: A40258
Vehicle #2: 1987 Massey-Ferguson 375 4WD, Perkins LD 31140, VIN: D12103

Observations: Same or possible improvement in mileage. No change of power, noise, smoothness, engine starting, or performance. Appears to be less exhaust smoke. Service differences unknown at this time. Would be willing to use biodiesel if it was the same price as petroleum diesel. "As stated in our environmental policy we are committed to identifying and promoting the most environmentally safe and sustainable business and farming practices. We are very interested in the possibility of using components of our waste stream in the production of biodiesel."

Car Rental Shuttle

1029 Wright Street
Oakland, CA 94621
Contact: Abdul Khan, 510-382-2140
Vehicle # 8102: 1981 RTS/GMC, Detroit6V92, VIN#1GOYT82JOBV811198, 99,131 miles
Vehicle # 8128: 1981 RTS/GMC, Detroit6V92,

VIN# 1GOYT82JXBV810754, 176,353 miles

Vehicle # 8142: 1981 RTS/GMC, Detroit6V92,

VIN# 1GOYT82JXBV810771, 622,349

Vehicle # 8145: 1981 RTS/GMC, Detroit6V92,

VIN# 1GOYP82J2BV810795, 241,649

Observations: No change in mileage, power, engine noise or maintenance. Checking on engine smoothness and starting. No Comments from drivers or fleet managers. They would use biodiesel if was the same price or $.10 a gallon more than petroleum diesel because it is the right thing to do and it is required by the Port of Oakland and the Rental Car Committee.

Ecology Center

1231 Second Street

Berkeley, CA 94710

Contact: Dave Williamson 510-406-9347, Daniel Maher 510-527-1585

Vehicle # 560: 1993 Lodal SA-3070, Cummins BT5.9, 150,000 miles

Observations: 17% reduction in mileage for B100 and no discernable decrease for B20. No change in power or noise. Exhaust was noticeably cleaner. 85% decrease in opacity readings with B100. Significantly smoother. Engine starting with B100 in cooler weather require a short warm up time in the morning. Other than that there are not problems. No service differences if tanks are cleaned at the beginning, otherwise fuel filter changes may be necessary. The change to biodiesel was completely transparent to the drivers. Fleet manager feels that the most important thing is to properly manage the logistics tails by having clean tanks, filling the vehicles every night to reduce potential water condensations, use a biocide to manage microbial growth, and possibly change fuel lines with B100. Would use biodiesel if it were the same price as petroleum diesel. Compared to other alternative fuels it is the least expensive. Most people compare the price to petroleum disel and if it were the same price they would use it. The fleet manager would be willing to pay $.50 to $1 more for biodiesel. It is especially cost effective, given its benefits, in low mileage urban setting when compared to CNG or exhaust treatment devices. Prolonged use of B100 can affect electronic control sensors. Retains of each load delivered should be kept for quality control purposes. Fleet manager would like to see 5% biodiesel in all ULSD in California, and incentives for using B100 in low mileage urban applications such a garbage trucks, street sweepers, school buses, transit buses and construction equipment.

Peninsula Sanitation Service

339 Bonair Siding

Stanford, CA 93405

Contact: Thomas Ott, 650-321-4236

Vehicle # 4: 1999 Volvo M11, Cummins engine 34912154 (4/98),

VIN# 4VMDCMPE7XN766178, 239,387 miles

Vehicle # 31: 2000 Volvo, Cummins ISM 34997181 (3/00),

VIN# 4V2DC2UE6YN258318, 93,936 miles

Vehicle # 32: 2001 Volvo, Cummins ISM engine 34998178 (3/00)

VIN# 4V2DC6UE11N258529, 101,629 miles

Observations: The fleet manager did not tell his drivers or mechanics when he first introduced biodiesel so there would be a blind test. There were not driver comments, however one of the mechanics commented that the fuel looked different. Other than that there were no comments about noise, power, visual exhaust, starting, service differences or mileage. They would use biodiesel if I was the same price as petroleum. All things being equal they feel that it is an environmental feather in their cap. They would prefer to use biodiesel instead of the existing exhaust treatment retrofits which are costing them $10,000-$12,000 per truck. Their recommendation is to use biodiesel and let the OEM's incorporate the exhaust treatment devices on the new trucks. They would not use biodiesel if it were more expensive than biodiesel or was an alternative to the exhaust treatment device retrofit program. The fleet manager did indicate that he personally would use biodiesel even if it was slightly more expensive.

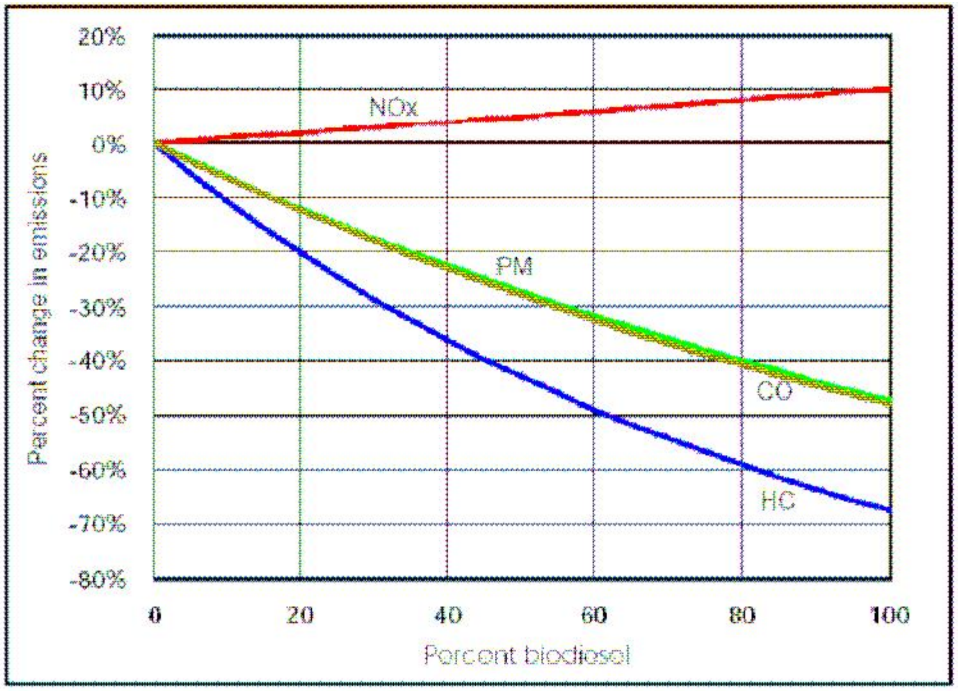
Task 9 – Emission Testing

9. Test, analyze, evaluate and compare the air emissions resulting from the use of the four different pilot project blends with petroleum diesel. Proivde emission test data for NOx and PM for at least five representative vehicles from each of the two selected test fleets from item 6 above.

Three series of emission test were conducted as part of this study. They were (1) Tailpipe Emissions in selected Bay Area fleets, (2) Engine dynamometer testing at the Combustion Analysis Laboratory at the University of California at Berkeley, and (3) engine dynamometer testing at Olson Ecologic Labs in Arcadia, California. Prior to reviewing the findings of these three tests it is important to understand the results of emission research that has already been conducted. The USEPA has compiled and summarized the most credible biodiesel emission research in a report available at www.biodieselindustries.com.

Biodiesel reduces tailpipe particulate matter (PM), hydrocarbon (HC), and carbon monoxide (CO) emissions from most modern four-stroke CI engines. These benefits occur because the fuel (B100) contains 11% oxygen by weight. The presence of fuel oxygen allows the fuel to burn more completely, so fewer unburned fuel emissions result. This same phenomenon reduces air toxics, because the air toxics are associated with the unburned or partially burned HC and PM emissions. Testing has shown that PM, HC, and CO reductions are somewhat independent of the feedstock used to make biodiesel. The EPA reviewed 80 biodiesel emission tests on CI engines and has concluded that the benefits are real and predictable over a wide range of biodiesel blends (Insert#8). For the full report see www.biodieselindustries.com.

Insert #9 – Biodiesel Emissions from USEPA



Biodiesel has also been shown to increase nitrogen oxide (NO_x) emissions in many engines. Biodiesel does not contain nitrogen so the increasing NO_x phenomenon is not related to fuel nitrogen content. NO_x is created in the engine as the nitrogen in the intake air reacts at the high in-cylinder combustion temperatures. As with petroleum based diesel fuel, the exact composition of the biodiesel can also influence NO_x emissions. Data shows NO_x variability between the various biodiesel meeting ASTM D6751 of around 15%, with soybean oil based biodiesel producing the highest NO_x increase. This is similar to the variability observed for conventional diesel fuels spanning the range of the ASTM diesel fuel specifications (ASTM D975).

Dr. Robert McCormick of the US Department of Energy's National Rebewable Energy Laboratory recently completed a study which brings into questions the commonly held belief that biodiesel blends inevitably cause an increase in NOx (http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/38296.pdf). Dr. McCormick reported a 5% decrease in NOx on a series of transit buses tested on NREL's chassis dynamometer. He suspects that the results demonstrate some inherent differences between testing diesel engines on different sorts of dynamometers. A chassis dynamometer tests an entire vehicle with the engine and drive train in place, whereas an engine dynamometer just tests the engine. The USEPA requires that a chassis dynamometer be used to test gasoline vehicles, but allows an engine dynamometer to be used for diesels because of the large number of vehicle drive trains and bodies that the engines can be place in. Generally the chassis dynamometer is believed to give results that are more indicative the emission profile a vehicle will experience in the real world. It is possible that biodiesel may not in fact cause an increase in NOx when measured on more accurate emission testing equipment. As Dr. McCormick indicates in the conclusion of his study, more study is needed.

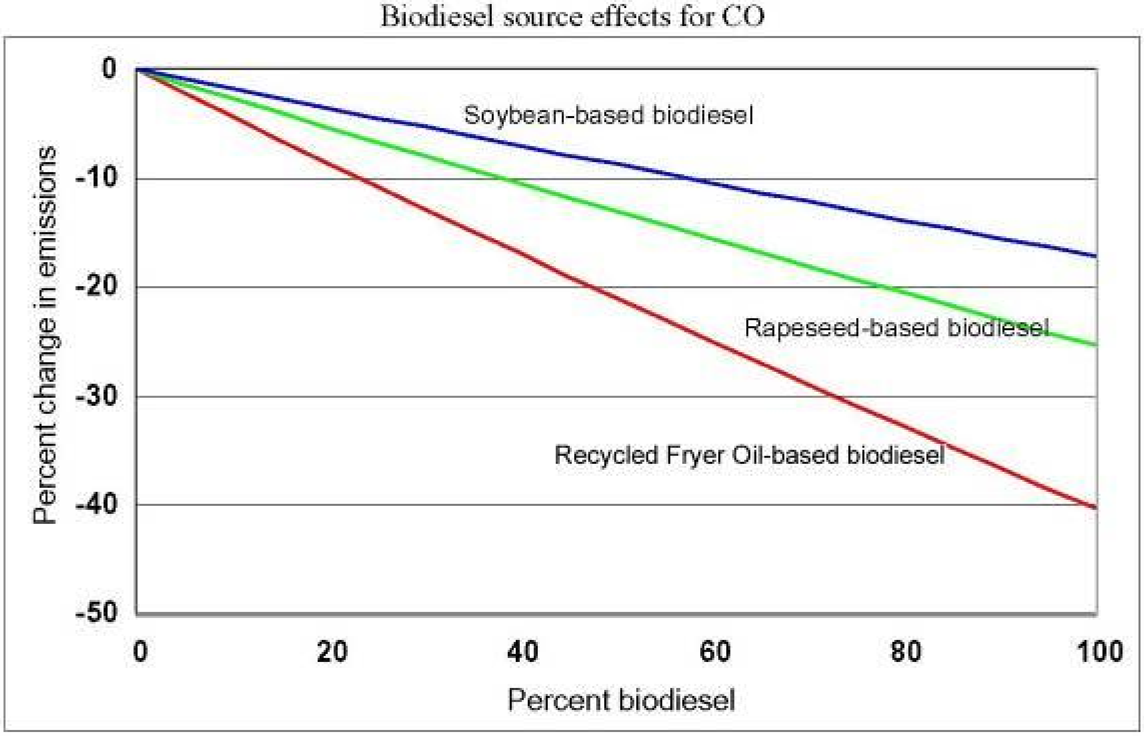
There are also significant questions raised about the emphasis placed upon controlling NOx as opposed to other criteria pollutants. It is generally accepted that NOx and hydrocarbons are the precursors to ozone and other photochemical smog. However recent studies have reported that on weekends in certain air basins when NOx emissions are lower, ozone levels increase, the so called “weekend effect.” This unexpected result brings into question the conventional wisdom that NOx is the delimiting factor as an ozone precursor. In fact it may be the balance of ozone coupled with hydrocarbons that is the true culprit. This issue is hotly debated and the jury is still out as to the verdict.

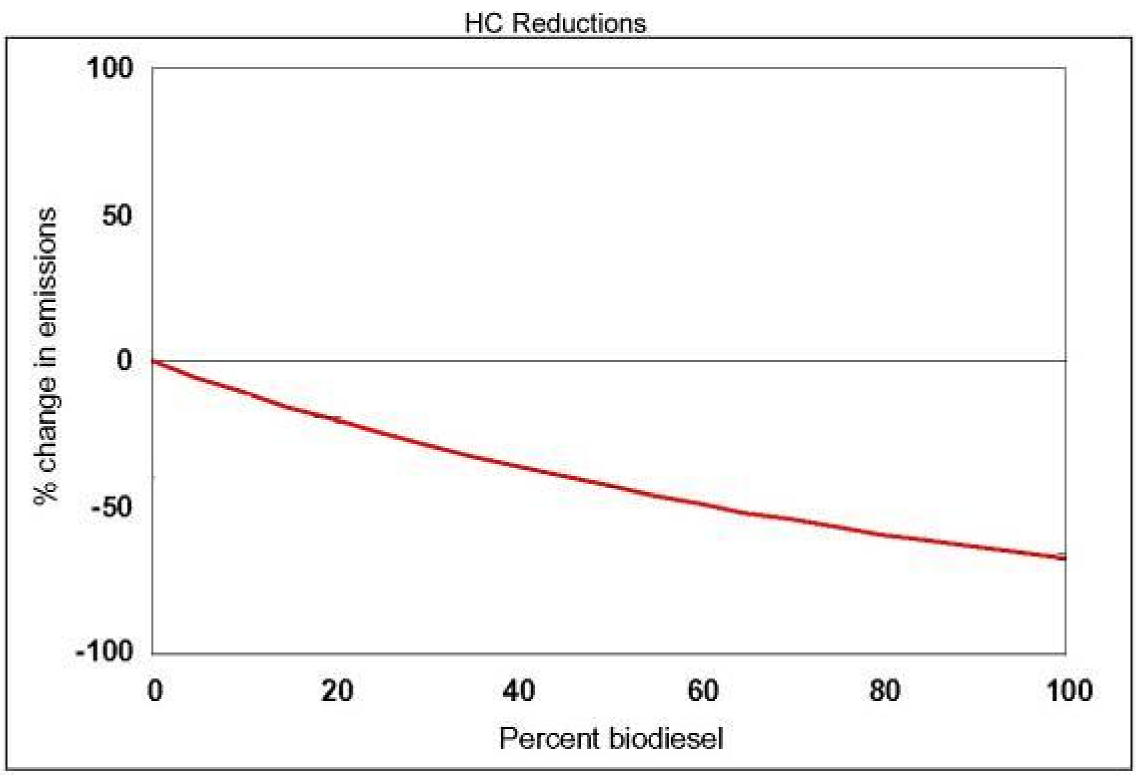
The conclusion then is that the assumption that biodiesel blends result in a NOx increase is in question, and that the benefits of reducing NOx may need to be balanced against the cumulative reductions of multiple criteria pollutants.

THE EFFECT OF FEEDSTOCK VARIATIONS ON EMISSIONS - As with petroleum-based fuels, the ASTM specifications for biodiesel allow for a variety of feedstocks and processes to be used to produce biodiesel. The specifications prescribe the amount of acceptable variability in the finished product. This variability is a compromise between maximizing the amount of fuel available for use and minimizing cost, while providing a minimum satisfactory level of engine performance.

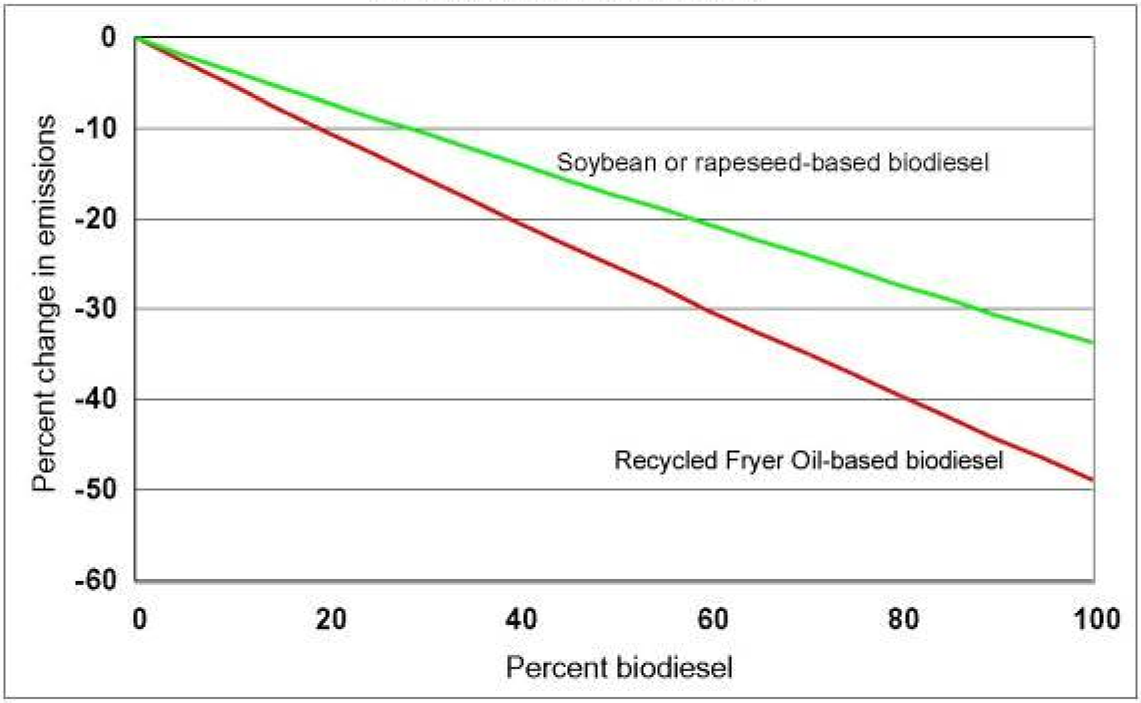
Since biodiesel is produced mainly as a whole cut fuel, where the goal is to take all of the vegetable oil or animal fat and turn it into biodiesel, some of the properties of finished biodiesel depend heavily on the feedstock. These properties can include cetane, cold flow, bulk modulus (compressibility and possibly the NOx effect), and stability. In addition, testing has shown that differing biodiesel properties can also lead to different levels of NOx emissions, although this does not appear to be the case with other regulated emissions (HC, CO, PM) or unregulated emissions (PAH, NPAH) or with open flame combustion in boilers or home heating applications. The following tables show the effects of feedstocks on emissions according to the USEPA (www.biodieselindustries.com):

Insert #10 – Biodiesel Emissions Based Upon Feedstock

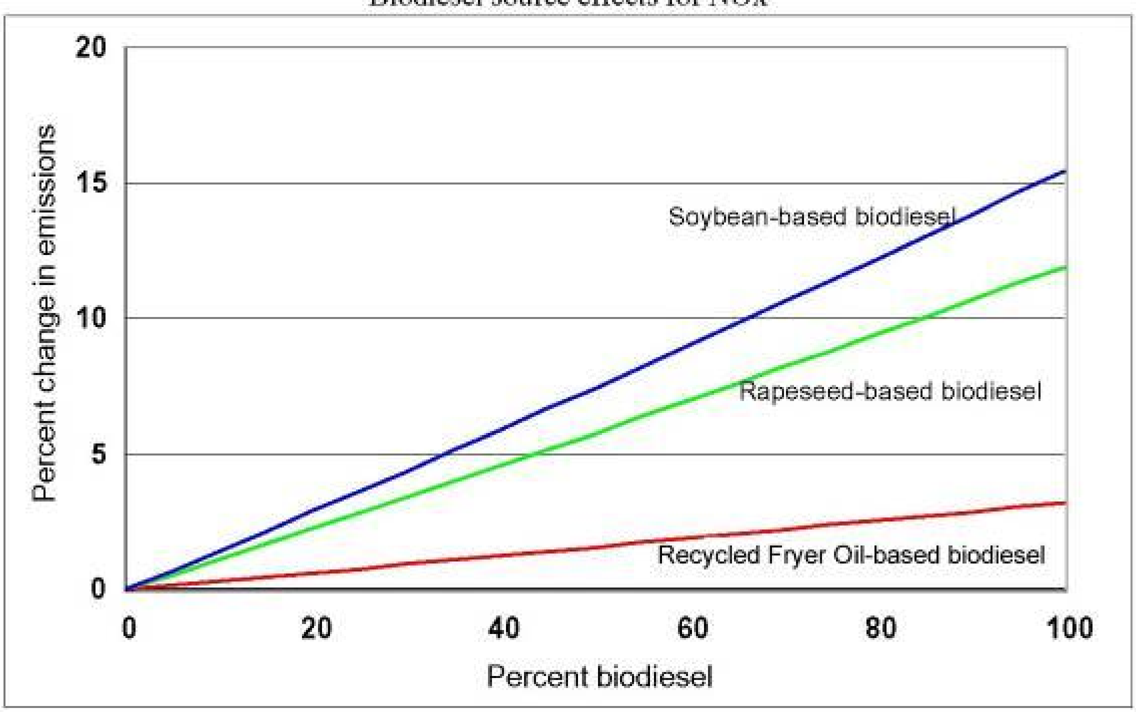




Biodiesel source effects for PM



Biodiesel source effects for NOx



It has been suggested in a study by Dr. McCormick that the difference in the emission characteristics is due to the saturation levels of the oils or fats that are used to make biodiesel. The more saturated feedstocks, such as recycled fryer oil and animal fat, have a higher cetane level and better emission profiles.

The following tests were run on a variety of feedstocks to test the emissions of different biodiesel blends and NOx reduction strategies.

1. Tailpipe Emission Testing

Tailpipe emission testing is generally conceded to be one of the least accurate methods of testing emissions because of the high degree of variability caused by uncontrollable variables such as climatic conditions. By testing a larger number of vehicles, some of this variability can be averaged out. The test parameters in the contract called for five vehicles, but nine were selected to increase the reliability of the consolidated data.

The emission testing equipment was obtained from Clean Air Instruments, and was a CARB and USEPA approved device, a Testo 350 M/XL. The device was calibrated before the tests were begun and was purged between tests on each vehicle. Protocols established for the device were followed to allow for readings to stabilize before they were recorded.

The reference fuel used in each test varied, but in each case was the petroleum diesel being used by the fleet. This ranged from off road diesel in the case of Benziger Winery, to CARB low sulfur diesel for the Car Rental Shuttle and Ecology Center, to CARB ultra low sulfur diesel for Peninsula Sanitation. The candidate fuel was B20, a 20% blend of biodiesel made from recycled fryer oil, with 80% of the reference petroleum diesel, and a NOx reduction additive. The tests were performed over a two week period from September 2-14, 2005 at approximately the same time of day for the vehicle being tested. The following results were observed and recorded (Insert #11). The actual printed readings can be found in Appendix A.

Insert #11 – Tailpipe Emission Testing Results

Tailpipe Emission Testing:
CARB Diesel vs. 20% Blend of Biodiesel with Additive

	Vehice	Type/ID#	Model	Fuel	RPM	CO*	HC*	Nox*	Total %
Benziger Winery		Tractor	Perkins						
Glen Ellen, CA	1	#1		Diesel	Idle	410	1970	128	
					High	746	470	168	
				B20+**	Idle	291	270	112	
					High	465	230	111	
	2	#2		Diesel	Idle	214	770	300	
					High	357	330	270	
				B20+	Idle	189	220	267	
					High	287	140	245	
	Total Diesel					1727	3540	866	
	Total B20+					1232	860	735	
	Change					-495	-2680	-131	
								-	-
	Percentage Change					-28.7%	-75.7%	15.1%	119.5%

	Vehice	Type/#ID	Model	Fuel	RPM	CO*	HC*	Nox*	Total %
Car Rental Shuttle		Shuttle Bus							
Oakland, CA	1	#8102		Diesel	Idle	68	380	127	
					High	122	570	97	
				B20+	Idle	63	180	117	
					High	145	530	88	
	2	#8128		Diesel	Idle	98	240	168	
					High	90	300	139	
				B20+	Idle	76	200	165	
					High	116	410	112	
	3	#8142		Diesel	Idle	92	280	159	
					High	163	310	105	
				B20+	Idle	80	280	149	
					High	130	490	99	
	Total Diesel					633	2080	795	
	Total B20+					610	2090	730	
	Change					-23	10	-65	
	Percentage Change					-3.6%	0.5%	-8.2%	-11.3%

	Vehice	Type/#ID	Model	Fuel	RPM	CO*	HC*	Nox*	Total %
Ecology Center		Garbage Truck							
Berkeley, CA	1	#560		Diesel	Idle	192	2180	317	
					High	338	2050	206	
				B20+	Idle	157	130	300	
					High	326	230	197	
	Total Diesel					530	4230	523	
	Total B20+					483	360	497	
	Change					-47	-3870	-26	
	Percentage Change					-8.9%	-91.5%	-5.0%	-105.3%

	Vehice	Type/#ID	Model	Fuel	RPM	CO*	HC*	Nox*	Total %
Peninsula Sanaitation		Garbage Truck							
Palo Alto, CA	1	#4		Diesel	Idle	70	130	357	
					High	190	230	221	
				B20+	Idle	86	0	328	
					High	256	0	240	
	2	#31		Diesel	Idle	69	310	263	
					High	140	340	246	
				B20+	Idle	69	280	345	
					High	141	140	240	
	3	#32		Diesel	Idle	73	1200	294	
					High	159	1390	253	
				B20+	Idle	65	530	243	
					High	130	810	233	
	Total Diesel					701	3600	1634	
	Total B20+					747	1760	1629	
	Change					46	-1840	-5	
	Percentage Change					6.6%	-51.1%	-0.3%	-44.9%

		CO*	HC*	Nox*	Total %
TOTALS					
	Total Diesel	3591	13450	3818	
	Total B20+	3072	5070	3591	
	Change	-519	-8380	-227	
	Average Percentage Change	**-14.5%**	**-62.3%**	**-5.9%**	**-82.7%**

*Parts per million
**Blend of 20% biodiesel, 80% diesel fuel used by fleet, and additive

These results show that B20 with a NOx reduction additive can reduce cumulative emissions by almost 83%, and NOx emissions by almost 6%.

2. Combustion Analysis Laboratory Testing – Engine Dynamometer

As mentioned earlier, tailpipe emission testing has certain inherent limitations and it was decided in consultation with BAAQMD staff that engine dynamometer testing would also be undertaken. Arrangements were made to have testing done under the direction of Professor Robert Dibble at the Combustion Analysis Laboratory at the University of California at Berkeley. Professor Dibble, with the support of some of his graduate students, ran the testing protocols on a Cummins 5.9 liter diesel installed at the Combustion Analysis Laboratory during the summer of 2004.

The reference diesel fuel used for the tests was CARB ultra low sulfur diesel (ULSD) procured from the British Petroleum distributor in San Jose, Western States Oil. The biodiesel used was made using the Mini Modular Production Unit from feedstocks acquired in the Bay Area consisting of virgin refined soybean oil and used fryer oil. These two types of biodiesel were selected because research published by the USEPA suggests that NOx emissions would be highest with soy based biodiesel and lowest with used fryer oil based biodiesel. Various blends of biodiesel and ULSD were tested, including 100% ULSD, 20% biodiesel with 80% ULSD, and 100% biodiesel. Additional tests were run to test the effects of an additive and a fuel/lubricating oil filtration system. The results are tabulated in the following table (Insert #10):

Insert #10 – Combustion Analysis Laboratory Test Results

Run	Reference Fuels-Run in 5.9L, 6 Cylinder, Cummins	Blend	Fuel Filter	Additive	Additive Concentration	Speed (RPM)	Load (%)	HC (ppm)	HC (%)	CO (ppm)	CO (%)	PM (filters) (mg/m^3)	PM (%)	Nox (ppm)	Nox (%)	Total (%)
1	CARB ULS Diesel	N/A	No	No	N/A	1800	80	16.2	0.0%	42.8	0.0%	3.0	0.0%	636	0.0%	0.0%
2	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	No	No	N/A	1800	80	12.8	-21.0%	39.2	-8.4%	2.7	-10.0%	646	1.6%	-37.8%
3	Biodiesel Produced from Virgin Soy Oil	B100	No	No	N/A	1800	80	10.0	-38.3%	36.3	-15.2%	2.3	-23.3%	720	13.2%	-63.6%
4	Biodiesel Produced from Virgin Soy Oil	B20	No	No	N/A	1800	80	10.8	-33.3%	37.9	-11.4%	1.9	-36.7%	645	1.4%	-80.0%
5	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	No	N/A	1800	80	7.7	-52.5%	33.3	-22.2%	2.2	-26.7%	656	3.1%	-98.3%
6	Biodiesel Produced from Virgin Soy Oil	B20	No	Yes	1:2000	1800	80	11.8	-27.2%	41.9	-2.1%	1.9	-36.7%	576	-9.4%	-75.4%
7	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	No	Yes	1:2000	1800	80	10.6	-34.6%	38.9	-9.1%	2.0	-33.3%	559	-12.1%	-89.1%
8	CARB ULS Diesel	N/A	No	Yes	1:2000	1800	80	7.4	-54.3%	37.0	-13.6%	1.9	-36.7%	632	-0.6%	-105.2%
9	CARB ULS Diesel	N/A	Yes	No	N/A	1800	80	12.2	-24.7%	39.2	-8.4%	2.5	-26.7%	510	-19.8%	-79.6%
10	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	Yes	No	N/A	1800	80	11.1	-31.5%	35.1	-18.0%	1.6	-46.7%	530	-16.7%	-112.9%
11	Biodiesel Produced from Virgin Soy Oil	B20	Yes	No	N/A	1800	80	12.8	-21.0%	40.9	-4.4%	1.5	-50.0%	528	-17.0%	-92.4%
12	Biodiesel Produced from Virgin Soy Oil	B100	Yes	No	N/A	1800	80	8.4	-48.1%	34.5	-19.4%	1.7	-43.3%	591	-7.1%	-117.9%
13	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	Yes	No	N/A	1800	80	6.8	-58.0%	31.7	-25.9%	2.1	-30.0%	601	-5.5%	-119.4%
14	Biodiesel Produced from Aggregate Used Vegetable Oil	B20	Yes	Yes	1:2000	1800	80	9.8	-39.5%	39.0	-8.9%	1.7	-43.3%	515	-19.0%	-110.7%
15	Biodiesel Produced from Virgin Soy Oil	B20	Yes	Yes	1:2000	1800	80	9.0	-44.4%	37.1	-13.3%	1.8	-40.0%	505	-20.6%	-118.3%
16	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	Yes	1:2000	1800	80	7.7	-52.5%	27.7	-35.3%	1.9	-36.7%	560	-11.9%	-136.4%
17	Biodiesel Produced from Virgin Soy Oil	B100	No	Yes	1:2000	1800	80	7.9	-53.3%	32.5	-24.1%	1.8	-40.0%	563	-11.5%	-128.8%
18	Biodiesel Produced from Virgin Soy Oil	B100	No	Yes	1:1000	1800	80	6.6	-59.3%	31.7	-25.9%	2.2	-26.7%	610	-4.1%	-115.9%
19	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	Yes	1:1000	1800	80	6.4	-60.5%	30.7	-28.3%	1.9	-36.7%	550	-13.5%	-139.0%
20	Biodiesel Produced from Aggregate Used Vegetable Oil	B100	No	Yes	1:4000	1800	80	5.3	-67.3%	32.4	-24.3%	2.0	-33.3%	554	-12.9%	-137.8%
21	Biodiesel Produced from Virgin Soy Oil	B100	No	Yes	1:4000	1800	80	5.2	-67.9%	32.1	-25.0%	1.8	-40.0%	559	-12.1%	-145.0%

There are several interesting results to note on this tabulation of results:

1. There were substantial cumulative emissions reduction benefits from all blends of biodiesel regardless of feedstock as high as 145%.

2. There were substantial NOx reductions using the additive with all biodiesel blends as high as 20.6%, and these same reductions were not observed when using the additive with CARB ULSD.

3. There were substantial emission reductions in all categories using the fuel/lube oil filter.

3. Olson-Ecologic Labs

This testing was performed by Olson-Ecologic Labs in Arcadia California in conformance with CARB and Texas Council of Environmental Quality Standards. The reference fuel was a low NOx, low aromatic TXLED diesel fuel (Texas Low Emission Diesel) that conformed to current low sulfur diesel standards. The candidate fuel was a 20% blend of biodiesel derived from crude cotton seed oil, 80% diesel fuel and an additive. The results showed almost a 3% reduction in NOx and led to Biodiesel Industries biodiesel blend being certified as the first and only low NOx certified biodiesel blend in Texas. Further testing is being conducted both privately and in conjunction with the National Biodiesel Board to have a low NOx biodiesel blend certified in California.

The final report from Olson-Ecologic Labs which documents the emission testing project conducted is attached as Appendix E. This project had the objective of showing emission equivalency between a B20 diesel candidate fuel treated with the proprietary polymer additive and the TXLED reference specification fuel when tested by the official EPA transient cycle emission test protocol. This project has been done in accordance with the detailed protocol and requirements specified by the Texas Commission for Environmental Quality in Austin, Texas.

Olson-Ecologic as an independent emission test laboratory is an ISO 2001:9000 registered facility. It is officially recognized and listed by EPA and CARB as a capable emission test facility for the protocols conducted in this project. All engine operation and transient cycle emission testing for this project was conducted on the Olson-EcoLogic 450 horsepower electric dynamometer.

The primary objective of this project was to demonstrate equivalency (or better) when comparing the B20 candidate fuel with additive treatment to the TXLED baseline reference fuel under identical test conditions, especially for NOx , PM and fuel consumption. Comparing the average of nine emission tests operating with the B20 candidate fuel with additive treatment to the average of six emission tests with the TXLED reference fuel resulted in the following comparisons and improvements for NOx, PM and Fuel Economy.

TxLed Reference fuel (six tests)

Grams per bhp-hr		lb per bhp-hr
NOx	PM	Fuel
5.040	0.213	0.3782

B20 Candidate Fuel with additive treatment (9 tests)

NOx	PM	Fuel
4.915	0.171	0.3634

Improvement with the B20 candidate fuel with additive treatment

NOx	PM	Fuel
2.5%	19.7%	3.9%

Discussion of Results:
The data in this report clearly indicate the statistical equivalency (or better) of the additive treated candidate fuel compared to the TXLED reference fuel. The statistical treatment of the average data (shown in the above summary) include the standard deviation and the +/- 95% confidence limits around the mean (or average) values for each set of data. The data variance from test to test was within the acceptable CFR standards for the test protocol and the regression coefficients for all tests were well within the CFR specified limits.

Insert #12 – TXLED Certification

Texas Low Emission Diesel Fuel (TxLED)
Alternative Diesel Fuel Formulation
Approval Notification

TCEQ

The alternative diesel fuel formulation listed herein has been demonstrated to the satisfaction of the executive director of the Texas Commission on Environmental Quality in accordance with the regulations specified under Title 30, Texas Administrative Code, Chapter 114, Subchapter H, Division 2, §114.315(c) to achieve comparable or better reductions in emissions of NOx, THC, NMHC, and PM to that of Texas Low Emission Diesel Fuel (TxLED). Therefore, the alternative diesel fuel formulation listed herein complies with the requirments specified under Title 30, Texas Administrative Code, Chapter 114, Subchapter H, Division 2, §114.312(f) and may be used to satisfy the requirements of §114.312(a) of this title.

Approval Date:	September 1, 2005
TCEQ Assigned Identification Number:	TXLED-A-00004
Approved alternative diesel fuel formulation:	Biodiesel Industries' B20 blend treated with [redacted] diesel fuel additive at a rate of 1 ounce to 20 gallons of B20 diesel fuel.
EPA Registration Number and Name:	"6228-123-11 Biodiesel B100 Methyl Esters" as registered by Biodiesel Industries, Inc. [redacted] - Not subject to EPA registration requirements.
Additive Identity:	Biodiesel Industries, Inc. B100 biodiesel. [redacted] This additive is a proprietary formulation [redacted]
Additive Minimum Concentration / Treatment Rate:	20% by volume Biodiesel Industries' B100 biodiesel per gallon of diesel fuel and 1 ounce of [redacted] additive per 20 gallons of blended B20 diesel fuel.
Base Diesel Fuel Specifications:	All base petroleum diesel fuels to be used for blending Biodiesel Industries' B20 diesel fuel must comply with the following specifications: • Any Grade No. 1-D or No. 2-D diesel fuel in compliance with ASTM D975-04c (Standard Specification for Diesel Fuel Oils) or current active version of ASTM D975, except for lubricity, may be used as the base fuel for blending this formulation.

4. NONREGULATED EMISSIONS

A. Greenhouse Gases (GHG) - Governor Scharzeneger recently signed Executive Order S-3-05 which establishes GHG reduction targets and charges the California Environmental Protection Agency Secretary, Alan Lloyd, with the coordination of the oversight of efforts to achieve them. The Secretary was directed to coordinate development and implementation of strategies to achieve the GHG reduction targets in conjunction with the secretary of Business, Transportation and Housing Agency, the secretary of the Department of Food and Agriculture, the secretary of the Resources Agency, the chairperson of the Air Resources Board, the chairperson of the Energy Commission and the president of the Public Utilities Commission.

According to the Governor, "California will continue to be a leader in the fight against global warming and protecting our environment. Today I am establishing clear and ambitious targets to reduce greenhouse gas emissions in our state to protect our many natural resources, public health, agriculture and diverse landscape. By working together we can meet the needs of both our economy and environment. Together we can continue California's environmental heritage and legacy of leadership in innovation in cutting-edge technology."

The targets the Governor announced call for a reduction of GHG emissions to 2000 levels by 2010; a reduction of GHG emissions to 1990 levels by 2020; and a reduction of GHG emissions to 80% below 1990 levels by 2050.

As acknowledged by Catherine Witherspoon at a recent California Air Resources Board meeting, biodiesel may play a significant role in achieving the Governor's GHG reduction targets. When biodiesel displaces petroleum, it reduces global warming gas emissions such as carbon dioxide (CO_2). When plants like soybeans grow they take CO_2 from the air to make the stems, roots, leaves, and seeds (soybeans). After the oil is extracted from the soybeans, it is converted into biodiesel and when burned produces CO_2 and other emissions, which return to the atmosphere. This cycle does not add to the net CO_2 concentration in the air because the next soybean crop will reuse the CO_2 in order to grow.

A complete lifecycle analysis performed by the National Renewable Energy laboratory reported that when fossil fuels are burned 100% of the CO_2 released adds to the CO_2 concentration levels in the air. Because fossil fuels are used to produce biodiesel, the recycling of CO_2 with biodiesel is not 100%, but substituting biodiesel for petroleum diesel reduces life-cycle CO_2 emissions by 78%. B20 reduces CO_2 by 15.66% (www.biodieselindustries.com).

B. Toxicity - Some PM and HC emissions from diesel fuel combustion are toxic or are suspected of causing cancer and other life threatening illnesses.

Using B100 can eliminate as much as 90% of these “air toxics.” B20 reduces air toxics by 20% to 40%. The effects of biodiesel on air toxics are supported by numerous studies, starting with the former Bureau of Mines Center for Diesel Research at the University of Minnesota. The Department of Energy (DOE) conducted similar research through the University of Idaho, Southwest Research Institute, and the Montana Department of Environmental Quality. The National Biodiesel Board conducted Tier I and Tier II Health Effects Studies that also support these claims (www.biodieselindustries.com).

C. Sulfur - By 2006, all U.S. highway diesel will contain less than 15 ppm sulfur—ultra low sulfur diesel fuel (ULSD). Currently highway diesel contains 500 ppm sulfur (or less). Biodiesel typically contains less than 15 parts per million (ppm) sulfur (sometimes as low as zero). Some biodiesel produced today may exceed 15 ppm sulfur, and those producers will be required to reduce those levels by 2006 if the biodiesel is sold into on-road markets.

In the on-road market, low-level blends of biodiesel such as 1% or 2% can improve lubricity of diesel fuels and this may be particularly important for ULSD as these fuels can have poor lubricating properties. Engine manufacturers depend on lubricity to keep moving parts, especially fuel pumps, from wearing prematurely. Even 2% biodiesel can restore adequate lubricity to dry fuels such as kerosene or Fischer-Tropsch diesel.

SUMMARY – All three emission tests documented significant cumulative and NOx specific emission reductions using various blends of biodiesel with a NOx reduction additive.

Task 10 – Cost Analysis

10. Analyze the cost of implementing the pilot project, including permitting and regulatory costs, developing infrastructure for the conversion of feedstocks to Biodiesel, disbursing the fuel, retrofit of vehicles, period of cost recovery and any other costs associated with developing the project.

The following scenarios illustrate some of the economics of biodisel production. The most significant factos include feedstock costs, labor, alcohol, and regulatory compliance. Finding a market for the glycerin produced and having an effective methanol recovery system can help mitigate costs.

SMALL PLANT ECONOMICS WITH FULL REGULATORY COMPLIANCE

Capacity	100 gallons per shift in 8 hours
	100,000 gallons per year in 8,000 hours

Production Equipment	$50,000
Vapor Recovery	$15,000
Truck & containers for oil collection	$50,000
Permitting	
EPA-NBB	$1,500
USDA – Bioenergy	$500
IRS Blender of Record	$1,600
CA Franchise Tax	$1,600
CA Department of Ag	$500
City	$1,500
Fire	$1,500
Air Management District	$1,500
Water discharge	$1,500
Electrical compliance	$3,000
Fire Safety	$1,000
OSHA Compliance	$3,000
HAZMAT containment	$1,600
CAPITAL COST	**$135,300**
Site Lease in proper zone	$12,000
Liability Insurance	$8,000
Vehicle maint, fuel, insurance	$12,000
General Administrative	$25,000
Utilities	$2,400
ANNUAL OPS COST	**$59,400**
Labor 8 hours @ $20 per hour	$160
Feedstock @ $.25 per gallon	$35

Methanol 25 gallons@ $2	$50
Sodium Hydroxide	$10
Additives	$3
Transportation @ $.10	$10
Testing $250 per 1,000 gal	$25
PRODUCTION COST p/gal	**$2.93**
ANNUAL OPS p/gal	**$.60**
CAP COST	**$.16**
TOTAL COST PER GALLON	**$3.69**
TOTAL ANNUAL COSTS	**$369,000**

REVENUE

Biodiesel sales @ $2.70	$270,000
Glycerin sales @ $1	$11,000
CCC Bioenergy @ $.40	$40,000
Blender's Credit @ $.50 x 40%	$20,000
TOTAL REVENUE	**$347,000**

NET PROFIT **-$22,000**

SMALL PLANT ECONOMICS WITHOUT REGULATORY COMPLIANCE

It is very difficult to make a profit with a small Biodiesel production unit and still be in compliance with all regulatory, safety, environmental and quality control concerns. This explains why many small producers choose to ignore these issues, and perform all of the labor themselves for "free" so there is an apparent return at the end of the year.

Capacity	100 gallons per shift in 8 hours 25,000 gallons per year in 2,000 hours

Production Equipment	$5,000
Truck and containers	$10,000
CAPITAL COST	**$15,000**

Vehicle maint, fuel, insurance	$12,000
Utilities	$600
ANNUAL OPS COST	**$12,600**

Feedstock @ $.25 per gallon	$35
Methanol 25 gallons@ $2	$50
Sodium Hydroxide	$10
Transportation @ $.10	$10

PRODUCTION COST p/gal	**$1.05**
ANNUAL OPS p/gal	**$.13**
CAP COST	**$.02**
TOTAL COST PER GALLON	**$1.20**
TOTAL ANNUAL COSTS	**$30,000**

REVENUE	
Biodiesel sales @ $2.50	$62,500
Glycerin sales @ $1	$11,000
TOTAL REVENUE	**$73,500**
NET PROFIT	**$43,000**

As with many activities, by ignoring regulatory, safety, environmental and quality requirements the underground Biodiesel producer can make a personal profit.

LARGE SCALE COMMERICAL PLANT ECONOMICS

Legitimate larger scale biodiesel production facilities can afford to maintain a quality control laboratory on site, and comply with all regulatory, safety and environmental standards. There are also economies of scale in terms of purchasing raw materials and the cost of labor per gallon.

Capacity	7,500 gallons per shift in 8 hours 6,000,000 gallons per year in 8,000 hours

Production Equipment	$6,000,000
Vapor Recovery	$150,000
Oil extraction system for virgin veg oil	$6,000,000
Trucks and containers for grease collection	$750,000
Permitting	
EPA-NBB	$7,500
USDA – Bioenergy	$1,500
IRS Blender of Record	$2,600
CA Franchise Tax	$2,600
CA Department of Ag	$1,500
City	$2,500
Fire	$2,500
Air Management District	$3,500
Water discharge	$3,500
Electrical compliance	$10,000
Fire Safety	$20,000
OSHA Compliance	$20,000
HAZMAT containment	$50,000
CAPITAL COST	**$13,027,700**

Site Lease in proper zone	$120,000
Liability Insurance	$80,000
General Administrative	$200,000
Advertising & marketing	$500,000
Customer support	$250,000
Utilities	$24,000
ANNUAL OPS COST	**$1,174,000**

For 7,500 gallons	per shift	per gallon
Labor 2 x 8 hours @ $25 per hour	$400	
Supervisory & lab time	$250	
TOTAL LABOR		$.09
Feedstock 20% @ $.25 p/gal		
80% @ $2.00 p/gal		
With 90% yield = $1.84	$13,750	$1.84
Methanol gallons@ $1.40	$1,575	$.21
Sodium Hydroxide	$750	$.10
Additives	$225	$.03
Transportation @ $.10	$750	$.10
	$17,700	$2.36

TOTAL COSTS	per year	per gallon
PRODUCTION COSTS	**$14,160,000**	**$2.36**
ANNUAAL OPS p/gal	**$1,174,000**	**$.20**
CAP COST	**$1,302,770**	**$.22**
TOTAL COSTS	**$16,636,770**	**$2.78**

TOTAL REVENUES	
Biodiesel sales @ $2.70	$16,200,000
Glycerin sales @ $.50	$330,000
CCC Bioenergy @ $.40	$2,400,000
Blender's Credit @ $.90 x 20%	$1,800,000
TOTAL REVENUE	**$20,010,000**

NET PROFIT	**$3,373 230**
Without government subsidies	**-$826,770**

From this analysis it can be seen that the single largest cost in making biodiesel is the cost of feedstocks. For Biodiesel to be competitive with petroleum diesel without government subsidies either the cost of petroleum diesel has to go up, or less expensive feedstock sources need to be found and developed.

Task 11 – Life Cycle Analysis of Biodiesel

11. Provide a quantitative comparison of the "cradle-to-grave" environmental impacts of the Biodiesel project with a no-project case.

A complete analysis was conducted as part of an Environmental Assessment under the National Environmental Policy Act for a biodiesel production facility located at Naval Base Ventura County. The result of the study was a "FONSI" or Finding of No Significant Impact. The no action alternative was weighted in light of the benefits of local biodiesel production. There is also an extensive biodiesel life cycle analysis conducted by the National Renewable Energy Laboratory. Both the Environmental Assessment and Life Cycle Analysis are available at http://biodieselindustries.com.

Task 12 – Write Final Report

12. Submit to DISTRICT a Report responding to the Scope of Work items 1 through 11 above.

This is the Final Report required under this task. Additional information may be obtained from the following sources:

Biodiesel Industries web site as an extensive amount of information and research reports at http://biodieselindustries.com.

The National Biodiesel Board has compiled an impressive library of online documents located at http://www.biodiesel.org/resources/reportsdatabase/.

The U.S. Department of Energy has some technical documents located at http://www.eere.energy.gov/biomass/document_database.html and with significant additional data at http://www.nrel.gov.

The EPA has reviewed many emission reports and has summarized them at http://www.epa.gov/OMS/models/biodsl.htm.

Iowa State University has an online tutorial on biodiesel at http://www.me.iastate.edu/biodiesel/Pages/biodiesel1.html.

Department of Defense A-A-59693A Biodiesel Commercial Item Description (CID) is located at http://assist.daps.dla.mil/docimages/0004/29/73/AA59693.PD0 in PDF format.

Conclusions

In conclusion, the prospect for implementing biodiesel production utilizing local resources is very good for the Bay Area. Objections based upon biodiesel NOx increases are being addressed with new NOx reduction strategies and new test protocols and results. The price of biodiesel is becoming more competitive with petroleum diesel as the result of increased petroleum prices and new federal subsidies for biodiesel.

Several small scale production facilities have already emerged in the Bay Area, and the distribution and use of biodiesel has accelerated widely over the past two years. Regulatory restrictions on the use of biodiesel have loosened somewhat because of the recognition of biodiesel's role in reducing greenhouse gases and as a renewable supplement to the fragile productive capacity of California's petroleum refineries.

Given these conditions, the production and use of biodiesel should increase in the Bay Area in the coming years.

APPENDIX A – Tailpipe Emission Results
1. Benziger Winery

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME Benziger #1
09/01/05 13:31:58
IDLE – 700RPM
Fuel: Fueloil #2

17.51	%	Oxygen
410	ppm	CO
1970	ppm	CxHy
80	ppm	NO
48.1	ppm	NO2
128	ppm	NOx
11	ppm	SO2
74.6	°F	Ta
246.2	°F	Tf
2.57	%	CO2
8.9	V	Batt.
0.88	1/m	Pump
75.9	%	Efficiency
444.2	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME Benziger #1
09/12/05 12:10:33
700RPM IDLE B20
Fuel: Fueloil #2

18.36	%	Oxygen
291	ppm	CO
270	ppm	CxHy
74	ppm	NO
37.9	ppm	NO2
112	ppm	NOx
14	ppm	SO2
68.1	°F	Ta
265.4	°F	Tf
1.93	%	CO2
9.3	V	Batt.
0.78	1/m	Pump
66.5	%	Efficiency
607.9	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME Benziger #2
09/01/05 14:00:50
RPM ~~1400~~ 700
Fuel: Fueloil #2

17.68	%	Oxygen
214	ppm	CO
770	ppm	CxHy
241	ppm	NO
58.4	ppm	NO2
300	ppm	NOx
12	ppm	SO2
80.9	°F	Ta
243.8	°F	Tf
2.44	%	CO2
9.1	V	Batt.
0.86	1/m	Pump
75.9	%	Efficiency
472.1	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME Benziger #2
09/12/05 12:00:10
RPM IDLE B20
Fuel: Fueloil #2

18.05	%	Oxygen
189	ppm	CO
220	ppm	CxHy
210	ppm	NO
57.3	ppm	NO2
267	ppm	NOx
17	ppm	SO2
61.9	°F	Ta
281.4	°F	Tf
2.17	%	CO2
9.2	V	Batt.
0.79	1/m	Pump
66.7	%	Efficiency
537.5	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME Benziger #1
09/01/05 13:44:57
RPM 1700
Fuel: Fueloil #2

15.58	%	Oxygen
746	ppm	CO
470	ppm	CxHy
142	ppm	NO
26.7	ppm	NO2
168	ppm	NOx
0	ppm	SO2
77.6	°F	Ta
497.3	°F	Tf
4.02	%	CO2
8.9	V	Batt.
0.88	1/m	Pump
65.7	%	Efficiency
258.8	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME
09/12/05 12:20:28
Benziger #1
Fuel: Fueloil #2
RPM 1700 B20

18.68	%	Oxygen
465	ppm	CO
230	ppm	CxHy
86	ppm	NO
25.3	ppm	NO2
111	ppm	NOx
2	ppm	SO2
68.0	°F	Ta
308.0	°F	Tf
1.70	%	CO2
9.3	V	Batt.
0.77	1/m	Pump
56.0	%	Efficiency
595.6	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME Benziger #2
09/01/05 14:08:38
RPM 1700
Fuel: Fueloil #2

15.25	%	Oxygen
357	ppm	CO
330	ppm	CxHy
243	ppm	NO
26.9	ppm	NO2
270	ppm	NOx
0	ppm	SO2
79.4	°F	Ta
522.6	°F	Tf
4.27	%	CO2
9.0	V	Batt.
0.80	1/m	Pump
65.8	%	Efficiency
239.8	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME Benziger #2
09/12/05 11:59:21
B20 1700RPM
Fuel: Fueloil #2

16.55	%	Oxygen
287	ppm	CO
140	ppm	CxHy
178	ppm	NO
67.2	ppm	NO2
245	ppm	NOx
17	ppm	SO2
58.8	°F	Ta
374.4	°F	Tf
3.29	%	CO2
9.2	V	Batt.
0.86	1/m	Pump
68.1	%	Efficiency
333.3	%	Excess air

APPENDIX A – Tailpipe Emission Results
2. Car Rental Shuttle

APPENDIX A – Tailpipe Emission Results
3. Ecology Center

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME EC 560
09/06/05 17:14:55
D2 RPM 800
Fuel: Fueloil #2

16.46	%	Oxygen
192	ppm	CO
2180	ppm	CxHy
243	ppm	NO
73.7	ppm	NO2
317	ppm	NOx
11	ppm	SO2
68.2	°F	Ta
207.7	°F	Tf
3.36	%	CO2
9.1	V	Batt.
0.84	l/m	Pump
82.7	%	Efficiency
326.1	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME EC 560
09/07/05 17:52:22
B20 IDLE
Fuel: Fueloil #2

18.33	%	Oxygen
157	ppm	CO
130	ppm	CxHy
235	ppm	NO
64.7	ppm	NO2
300	ppm	NOx
14	ppm	SO2
74.6	°F	Ta
222.2	°F	Tf
1.96	%	CO2
10.1	V	Batt.
0.78	l/m	Pump
73.6	%	Efficiency
599.9	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME EC 560
09/13/05 17:09:54
B50 - IDLE
Fuel: Fueloil #2

17.39	%	Oxygen
179	ppm	CO
2070	ppm	CxHy
224	ppm	NO
64.0	ppm	NO2
288	ppm	NOx
17	ppm	SO2
65.5	°F	Ta
221.6	°F	Tf
2.66	%	CO2
9.5	V	Batt.
0.77	l/m	Pump
78.1	%	Efficiency
428.8	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME EC 560
09/06/05 17:30:39
D2 RPM 1800
Fuel: Fueloil #2

14.41	%	Oxygen
338	ppm	CO
2050	ppm	CxHy
130	ppm	NO
75.6	ppm	NO2
206	ppm	NOx
15	ppm	SO2
67.2	°F	Ta
318.1	°F	Tf
4.90	%	CO2
9.1	V	Batt.
0.83	l/m	Pump
80.0	%	Efficiency
198.8	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME EC 560
09/07/05 17:57:54
B20 High
Fuel: Fueloil #2

17.52	%	Oxygen
326	ppm	CO
230	ppm	CxHy
119	ppm	NO
77.6	ppm	NO2
197	ppm	NOx
16	ppm	SO2
74.6	°F	Ta
308.1	°F	Tf
2.56	%	CO2
10.1	V	Batt.
0.79	l/m	Pump
69.4	%	Efficiency
446.8	%	Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME EC 560
09/13/05 17:19:18
1700 B50
Fuel: Fueloil #2

15.99	%	Oxygen
259	ppm	CO
2290	ppm	CxHy
115	ppm	NO
60.5	ppm	NO2
176	ppm	NOx
8	ppm	SO2
66.3	°F	Ta
336.8	°F	Tf
3.71	%	CO2
9.5	V	Batt.
0.79	l/m	Pump
74.2	%	Efficiency
287.5	%	Excess air

APPENDIX A – Tailpipe Emission Results
4. Peninsula Sanitation Service

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI #31
09/12/05 18:41:18
IDLE
Fuel: Fueloil #2
18.58 % Oxygen
69 ppm CO
310 ppm CxHy
220 ppm NO
43.4 ppm NO2
263 ppm NOx
12 ppm SO2
75.8 °F Ta
214.0 °F Tf
1.77 % CO2
9.2 V Batt.
0.78 l/m Pump
72.9 % Efficiency
667.9 % Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI #31 B20
09/01/05 17:39:46
RPM 675
Fuel: Fueloil #2
18.07 % Oxygen
69 ppm CO
280 ppm CxHy
297 ppm NO
48.2 ppm NO2
345 ppm NOx
14 ppm SO2
87.2 °F Ta
190.1 °F Tf
2.15 % CO2
9.0 V Batt.
0.58 l/m Pump
81.0 % Efficiency
543.6 % Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI-32
09/12/05 18:16:10
IDLE 700
Fuel: Fueloil #2
17.95 % Oxygen
73 ppm CO
1200 ppm CxHy
251 ppm NO
43.1 ppm NO2
294 ppm NOx
5 ppm SO2
78.5 °F Ta
197.0 °F Tf
2.24 % CO2
9.1 V Batt.
0.78 l/m Pump
79.6 % Efficiency
520.1 % Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI #32
09/01/05 17:18:56
B20 RPM 700
Fuel: Fueloil #2
17.55 % Oxygen
65 ppm CO
530 ppm CxHy
210 ppm NO
32.8 ppm NO2
243 ppm NOx
8 ppm SO2
88.8 °F Ta
195.1 °F Tf
2.54 % CO2
8.9 V Batt.
0.87 l/m Pump
82.6 % Efficiency
452.1 % Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI #31
09/12/05 18:44:11
1500
Fuel: Fueloil #2
17.91 % Oxygen
140 ppm CO
340 ppm CxHy
192 ppm NO
54.2 ppm NO2
246 ppm NOx
12 ppm SO2
77.0 °F Ta
281.2 °F Tf
2.27 % CO2
9.2 V Batt.
0.77 l/m Pump
69.7 % Efficiency
510.9 % Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI #31
09/01/05 17:48:38
RPM 1500
Fuel: Fueloil #2
17.80 % Oxygen
141 ppm CO
140 ppm CxHy
186 ppm NO
54.1 ppm NO2
240 ppm NOx
14 ppm SO2
86.5 °F Ta
314.0 °F Tf
2.36 % CO2
9.1 V Batt.
0.86 l/m Pump
67.9 % Efficiency
491.1 % Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI-32
09/12/05 18:18:01
1500 RPM
Fuel: Fueloil #2
17.16 % Oxygen
159 ppm CO
1390 ppm CxHy
200 ppm NO
53.3 ppm NO2
253 ppm NOx
8 ppm SO2
74.9 °F Ta
246.3 °F Tf
2.83 % CO2
9.1 V Batt.
0.78 l/m Pump
77.6 % Efficiency
399.3 % Excess air

Asset #202740
Testo t350 XL
SN: 00708752 /USA
NONAME PSSI #32
09/01/05 17:31:12
B20 RPM 1500
Fuel: Fueloil #2
17.37 % Oxygen
130 ppm CO
810 ppm CxHy
188 ppm NO
44.5 ppm NO2
233 ppm NOx
8 ppm SO2
89.7 °F Ta
305.2 °F Tf
2.67 % CO2
9.1 V Batt.
0.86 l/m Pump
72.2 % Efficiency
426.6 % Excess air

APPENDIX B – Fleet Surveys
1. Benziger Winery (a)

09/10/2005 22:48 7079354049 BENZIGER WINERY PAGE 01

BIODIESEL INDUSTRIES INC.

PRODUCTION • TECHNOLOGY • DEVELOPMENT

Thank you for participating in this demonstration and evaluation program of biodiesel being conducted by Biodiesel Industries and Western States Oil in conjunction with the Bay Area Air Quality Management District. For each participating vehicle please complete the following information. If you have any questions you may contact:

Joe Steinberger, Bay Area Air Quality Management District, 415-749-5018,
Russell Teall, Biodiesel Industries, 805-683-8103, or,
Bob Brown, Western States Oil, 408-351-2328

Fleet Owner Name: Benziger Family Winery

Address: 1883 London Ranch Rd
Glen Ellen, CA. 95442

Fleet Manager Name: Matt Atkinson Phone Number (707) 486-3906

Vehicle Make: Massey-Ferguson Model: 375 4WD VIN: D12103

Engine Make: Perkins Model: 4D 31140 U675306A Age: 1987

Beginning Test Date: _____ Odometer Mileage: N/A

Ending Test Date: _____ Odometer Mileage: NA

Please provide any emission test data gathered on a separate sheet: Yes_____ No_____

Indicate any change in mileage: Same or possible improvement

Indicate any change in power: None noticed

Indicate any change in noise: None

Indicate any change in visual exhaust: Appears to be less exhaust smoke

Indicate any change in engine smoothness: None noticed

Indicate any change in engine starting: None

Indicate any service differences: unknown at this time

APPENDIX B – Fleet Surveys
1. Benziger Winery (b)

09/18/2005 22:40 7079354049 BENZIGER WINERY PAGE 02

BIODIESEL INDUSTRIES INC.

PRODUCTION • TECHNOLOGY • DEVELOPMENT

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Russell Teall, Biodiesel Industries, 805-683-8103, or,
Bob Brown, Western States Oil, 408-351-2328

Fleet Owner Name: Benziger Family Winery

Address: 1883 London Ranch Rd
Glen Ellen, CA. 95442

Fleet Manager Name: Matt Atkinson Phone Number: (707) 486-3906

Vehicle Make: Massey-Ferguson Model: 375 4WD VIN: A40258

Engine Make: Perkins Model: LD31140 U533565W Age: 1987

Beginning Test Date: ___ Odometer Mileage: NA

Ending Test Date: ___ Odometer Mileage: NA

Please provide any emission test data gathered on a separate sheet: Yes___ No___

Indicate any change in mileage: ___

Indicate any change in power: ___

Indicate any change in noise: ___

Indicate any change in visual exhaust: ___

Indicate any change in engine smoothness: ___

Indicate any change in engine starting: ___

Indicate any service differences: ___

APPENDIX B – Fleet Surveys
1. Benziger Winery (c)

Indicate any driver comments: No difference in performance overall has been observed at this time. fuel has only been in use for one week.

Indicate any fleet manager comments: : Too early in test to determine any changes

Would you be willing to use Biodiesel if it were the same price as petroleum diesel? Yes

Why/why not? : As stated in our environmental policy we are committed to identifying and promoting the most environmentally safe and sustainable business and farming practices.

Would you be willing to use Biodiesel if it were $.10 per gallon more expensive than petroleum diesel? Yes

Why/why not? : for the same reason as above

Any other comments about biodiesel fuel? : We are very interested in the possibility of using components of our waste stream in the production of biodiesel.

When completed please fax to:
Russell Teall 805-[redacted]
456-2192

APPENDIX B – Fleet Surveys
2. Car Rental Shuttle (a)

BIODIESEL INDUSTRIES INC.

PRODUCTION • TECHNOLOGY • DEVELOPMENT

Thank you for participating in this demonstration and evaluation program of biodiesel being conducted by Biodiesel Industries and Western States Oil in conjunction with the Bay Area Air Quality Management District. For each participating vehicle please complete the following information. If you have any questions you may contact:

Joe Steinberger, Bay Area Air Quality Management District, 415-749-5018,
Russell Teall, Biodiesel Industries, 805-683-8103, or,
Bob Brown, Western States Oil, 408-351-2328

Fleet Owner Name: Car Rental Center

Address: 1029 Wright Street
Oakland, CA 94621

Fleet Manager Name: Abdul Khan Phone Number: 510-382-2140

Vehicle Make: GMC Model: RTS VIN: NOTED for all 4

Engine Make: Detroit Model: 6V92 Age: 1981

Beginning Test Date: 9/12 Odometer Mileage: 600-700 K

Ending Test Date: 9/13 Odometer Mileage: _____

Please provide any emission test data gathered on a separate sheet: Yes_____ No_____

Indicate any change in mileage: Nothing yet

Indicate any change in power: NO

Indicate any change in noise: NO

Indicate any change in visual exhaust: yes

Indicate any change in engine smoothness: ?

Indicate any change in engine starting: ?

Indicate any service differences: Same

APPENDIX B – Fleet Surveys
2. Car Rental Shuttle (b)

Indicate any driver comments: NO

Indicate any fleet manager comments: : NO

Would you be willing to use Biodiesel if it were the same price as petroleum diesel? yes

Why/why not? : RIGHT Thing to do

Would you be willing to use Biodiesel if it were $.10 per gallon more expensive than petroleum diesel? yes

Why/why not? : Port of Oakland requires it Rental Car Committee

Any other comments about biodiesel fuel? : NO

When completed please fax to:
Russell Teall 805-[redacted]
456-2192

APPENDIX B – Fleet Surveys
3. Ecology Center (a)

BIODIESEL INDUSTRIES INC.

PRODUCTION • TECHNOLOGY • DEVELOPMENT

Thank you for participating in this demonstration and evaluation program of biodiesel being conducted by Biodiesel Industries and Western States Oil in conjunction with the Bay Area Air Quality Management District. For each participating vehicle please complete the following information. If you have any questions you may contact:

Joe Steinberger, Bay Area Air Quality Management District, 415-749-5018,
Russell Teall, Biodiesel Industries, 805-683-8103, or,
Bob Brown, Western States Oil, 408-351-2328

Fleet Owner Name: Ecology Center

Address: 1231 2nd Street
Berkeley CA 94710

Fleet Manager Name: Dave Williamson / Daniel Maher Phone Number: 510-527-1585, Sarah 527-5555

Vehicle Make: Lodal Model: SA-3070 VIN:

Engine Make: Cummins Model: B5.9 Age: 1993

Beginning Test Date: Odometer Mileage: 150,000

Ending Test Date: Odometer Mileage:

Please provide any emission test data gathered on a separate sheet: Yes ✓ No

Indicate any change in mileage: yes, 17% decrease w/ B100, B20 No discernable decrease

Indicate any change in power: None

Indicate any change in noise: none

Indicate any change in visual exhaust: Biodiesel is substantially clean than dino. diesel, 85% decrease in opacity w/ B100

Indicate any change in engine smoothness: Significantly smoother

Indicate any change in engine starting: In cooler temps B100 requires short warmup time other than that none

Indicate any service differences: None, if individual fuel tank clean, otherwise change of fuel filter needed

APPENDIX B – Fleet Surveys
3. Ecology Center (b)

Indicate any driver comments: Completely transparent to drivers

Indicate any fleet manager comments: : most important thing is to manage logistics [illegible] - clean tanks, fill every night, change fuel lines, use biocide

Would you be willing to use Biodiesel if it were the same price as petroleum diesel? yes

Why/why not? : compared to other alt fuels it is the least expensive, most people compare it to petro & if it were the same price most people would use it

Would you be willing to use Biodiesel if it were $.10 per gallon more expensive than petroleum diesel? yes

Why/why not? : would pay $.50-$1 more, Biodiesel is cost effective, low milage especially give benefits in urban area, less expensive than CNG or Exhaust treatment

Any other comments about biodiesel fuel? : prolonged use of B100 can affect electronic control sensor. Retains of each load needed & inspection of fuel. would like to see a requirement that all ULSD have 5% Biodiesel in CA. Encourage more B100 in low milage high population areas, garbage, street sweepers, school buses, transit buses & construction equipment

When completed please fax to:
Russell Teall 805-456-~~[illegible]~~ 456-2192

APPENDIX B – Fleet Surveys
4. Peninsula Sanitation Service (a)

BIODIESEL INDUSTRIES INC.

PRODUCTION • TECHNOLOGY • DEVELOPMENT

Thank you for participating in this demonstration and evaluation program of biodiesel being conducted by Biodiesel Industries and Western States Oil in conjunction with the Bay Area Air Quality Management District. For each participating vehicle please complete the following information. If you have any questions you may contact:

Joe Steinberger, Bay Area Air Quality Management District, 415-749-5018,
Russell Teall, Biodiesel Industries, 805-683-8103, or,
Bob Brown, Western States Oil, 408-351-2328

Fleet Owner Name: Peninsula Sanitation Service

Address: 339 Banain Siding
Stanford CA 93405

Fleet Manager Name: Tom Ott Phone Number: 650-321-4236

Vehicle Make: #'s 31+32 Model: See report VIN: ______

Engine Make: ______ Model: ______ Age: ______

Beginning Test Date: ______ Odometer Mileage: ______

Ending Test Date: ______ Odometer Mileage: ______

Please provide any emission test data gathered on a separate sheet: Yes ____ No ____

Indicate any change in mileage: not yet

Indicate any change in power: NO, only mechanic noticed, blind #5

Indicate any change in noise: NO

Indicate any change in visual exhaust: NO

Indicate any change in engine smoothness: NO

Indicate any change in engine starting: NO

Indicate any service differences: NO

APPENDIX B – Fleet Surveys
4. Peninsula Sanitation Service (b)

Indicate any driver comments: NO

Indicate any fleet manager comments: : NO,

Would you be willing to use Biodiesel if it were the same price as petroleum diesel? Yes

Why/why not? : all things being equal, environmental feather in our cap, biofuel instead of Retrofits, Let OEM's do changes $10-12K per truck

Would you be willing to use Biodiesel if it were $.10 per gallon more expensive than petroleum diesel? NO

Why/why not? : would personally but company would not unless the exhaust treatment device no brainer

Any other comments about biodiesel fuel? : worthwhile, retrofits to trucks are expensive + impacts on bottom line

TOMO @ PSSI.STANFORD.EDU

When completed please fax to:
Russell Teall 805-[redacted]
456-2182

APPENDIX C – CA GHG Reduction Targets

OFFICE OF THE GOVERNOR

Governor Schwarzenegger Establishes Green House Gas Emission Reduction Targets

Governor Arnold Schwarzenegger today announced greenhouse gas (GHG) emission reduction targets for California at the United Nations World Environment Day in San Francisco. The Governor signed Executive Order S-3-05 which establishes these GHG targets and charges the California Environmental Protection Agency secretary with the coordination of the oversight of efforts to achieve them.

"California will continue to be a leader in the fight against global warming and protecting our environment. Today I am establishing clear and ambitious targets to reduce greenhouse gas emissions in our state to protect our many natural resources, public health, agriculture and diverse landscape," said Governor Schwarzenegger. "By working together we can meet the needs of both our economy and environment. Together we can continue California's environmental heritage and legacy of leadership in innovation in cutting-edge technology."

The targets the Governor announced today call for a reduction of GHG emissions to 2000 levels by 2010; a reduction of GHG emissions to 1990 levels by 2020; and a reduction of GHG emissions to 80% below 1990 levels by 2050.

California's scientists lead the world in developing the basis for evaluating the impacts of GHG emissions. Many California companies have taken significant steps to reduce GHG emissions from their operations and to develop products that will reduce GHG emissions.

California is vulnerable to the impacts of climate change through the reduction in the quality and supply of water to the state from the Sierra snow pack; the exacerbation of California's air quality problems; the adverse impact on human health by increasing heat stress and related deaths, incidence of infectious disease, and risk of asthma, respiratory and other health problems; the rise in sea level along the 1,100 miles of coastline; and detrimental impacts to agriculture due to increased temperatures, diminished water supply and changes in the abundance and distribution of pests.

"Technologies that reduce GHG emissions are increasingly in demand in the worldwide marketplace," said California Environmental Protection Agency Secretary Alan Lloyd. "California companies investing in these technologies are well placed to benefit from this demand. This will boost California's economy and protect public health and the environment."

The California Environmental Protection Agency secretary will coordinate development and implementation of strategies to achieve the GHG reduction targets in conjunction with the secretary of Business, Transportation and Housing Agency, the secretary of the Department of Food and Agriculture, the secretary of the Resources Agency, the chairperson of the Air Resources Board, the chairperson of the Energy Commission and the president of the Public Utilities Commission. The work of the agencies will build on the efforts underway at the Air Resources Board, the Energy Commission and the Public Utilities Commission. The secretary will report to the Governor and the Legislature on progress made, mitigation and adaptation proposals and options for a GHG emission cap and trade systems to reduce GHG emissions in the most cost effective manner possible. Executive Order S-3-05 requires the secretary to make the first report on progress to the Governor and the Legislature by January 2006.

Appendix D – List of Retail Biodiesel Locations in California

California

Business Name/Location (Sort by City, Sort by Blend)		Contact	Phone	Blend	Restrictions
Bay Area Diablo Petroleum 3575 Pacheco Blvd Martinez, CA 94553	Google Maps	Jack Bene	925-372-5406	B100	Any Blend Available. Open 7-4 M-F. Credit Cards accepted.
BioFuel Oasis 2465 - 4th St. Berkeley, CA 94710	Google Maps	Gretchen Zimmerman	510-665-6609	B99	Sun, Tue, Thur. 4-8pm, Fri & Sat 10-5pm, Cash or Check
Eel River Fuels, Inc 3371 North State Street Ukiah, CA 95482	Google Maps	Ken H. Foster / Al Banta	707-462-5554	B99	24/7, All Major Credir Cards
ITL, Inc. 8330 Atlantic Avenue Cudahy, CA 90201	Google Maps	Mike Rohrer	323-562-3230	B20	Premium B20 at the pump - credit card or cash accepted
McCormix Corporation 22 N. Calle Cesar Chavez Santa Barbara, CA 93117	Google Maps	Ken Olsen	805-963-9366	B20, B100	6am - 5pm
McCormix Corporation 55 Depot Rd. Goleta, CA 92117	Google Maps	Ken Olsen	805-963-9366	B20	24 hours a day
Pacific Biofuel 1601 Jarvis Rd Santa Cruz, CA 95065	Google Maps	Ray Newkirk	831-459-6774	B100	Retail purchasers must call ahead
Renner Petroleum/World Energy 76 Bear Canyon Rd. Garberville, CA 95542	Google Maps		707-443-1645	B20	public/no restrictions
RTC Fuels, LLC 4067 El Cajon Blvd. San Diego, CA 92105	Google Maps	Mike McCallen	619-521-2469	B20	
San Francisco Petroleum 4290 Santa Rosa Avenue Santa Rosa, CA 95407	Google Maps	Rod Martin	707-586-2765	B100	
Solar Living Institute 13771 South Highway 101 Hopland, CA 95449	Google Maps		707-744-2017	B100	M-F 8:30 - 5:30 / Sat/Sun 10-5
Solar Living Institute 13771 S. Highway 101 Hopland, CA 95449	Google Maps		707-744-2017	B100	M-F 9-6
T.W. Brown Oil 1457 Fleet Ave. Ventura, CA 93003	Google Maps	Ted Brown, Sr.	805-339-2355	B20, B99	
The Biofuel Station 44440 Highway 101 Laytonville, CA 95454	Google Maps	Kimber or Eric	707-984-6818	B100	M-F 9-5
Toro Petroleum Corp 2109 Fremont St Monterey, CA 93940	Google Maps	James Hill	831-424-1691	B20	
Ventura Harbor Marine Fuel, Inc. 1449 Spinnaker Dr. Ventura, CA 93001	Google Maps		805-644-4046	B100	public
Western States Oil 1790 S. 10th San Jose, CA 95112	Google Maps				open 9-5 M-F; cash or credit card
Yokayo Biofuels 150 Perry Street Ukiah, CA 95482	Google Maps	Kumar Plocher	877-806-0900	B100	M-F 9-5; Cash, Check, MC/Visa