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Feasibility Study of Biodiesel Production and Use in West Oakland

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Table of Contents

List of Figures and Tables

Abstract:

Toxic diesel emissions, in and around the community of West Oakland, burden the community with intractable health problems. Numerous scientific studies link diesel emissions to lung cancer, reproductive system damage, asthma, asthma aggravation, and respiratory illness. Importantly, economic feasibility has an integral influence on decisions that affect the environment. Biodiesel, specifically transesterified vegetable oils or used fryer oils, are becoming continuously economically competitive with diesel fuel as the national biodiesel market expansion leads to economies of scale for fuel producers. Compared to California Certified Diesel #2, biodiesel reduces Diesel Particulate Matter, Carbon Monoxide, Hydrocarbons, Greenhouse gas, and sulfates, among other toxic pollutants. Notably, the use of biodiesel at marine vessel ports decreasing operating costs by creating both a local and centralized market which by decreasing transportation costs and consolidating sales and use, resulting in a decrease of toxic diesel emissions in communities surrounding the ports. Expert management skills are required to operate a large scale biodiesel production facility, and quality control is imperative; therefore producers must obtain ASTM standardization.

Keywords: Diesel Emissions, Asthma. Diesel emissions and health (costs) Chemical Structure, Fuel Properties, Cetane, Iodine number, diesel health issues ,environmental justice, NOx, PM, CO, DTBP, EHN. Use-Specific Price Elasticity. Market Penetration.

0. Introduction

Agriculturally produced biofuel propelled Otto Diesel's original car, but fossil oil has dominated supply for the past century, slowly depleting available cheap fossil supplies and wrecking havoc on the environmental quality of communities near large diesel fuel consumers.

In West Oakland, California, local community consensus developed through the West Oakland Toxics Reduction Collaborative (WOTRC) is to "ditch dirty diesel!" Activities associated with shipping, receiving and moving freight containers through the Port of Oakland generates diesel truck, train, and marine vessel emissions, as well as construction equipment exhaust that pollutes local air to hazardous levels. Low income minority residents of West Oakland bear the burden of health risks associated with diesel exhaust emissions, and they have done so throughout the community's long history of incompatible land uses.

The community has identified biodiesel as one option to supplant dirtier conventional fuel sources and formed the Clean Fuels subcommittee of the WOTRC to work toward that goal. This research examines several social, economic, logistical, and environmental dimensions to contribute to the implementation of large scale production and use of biodiesel in West Oakland. This report addresses these dimensions through the following analyses:

- biodiesel production methodology
- biodiesel emission chemistry
- Quantification of PM emissions reductions achieved at various levels of biodiesel use in West Oakland

- Macroeconomic analysis of past biodiesel use trends and market forecasts
- Microeconomic analysis to quantify diesel demand at the Port of Oakland
- Description of the biodiesel supply chain in the Bay Area
- Quantification of waste grease feedstock in the Bay Area and discussion of the benefits and limitations of using waste grease for biodiesel
- Methods of transesterification to manufacture biodiesel are explained and diagramed
- Soy oil and waste grease are the two major feedstock inputs for biodiesel production yet their wholesale price and available supply are very uncertain, so a sensitivity analysis is presented to assess price and supply volatility and to consider the effect of exogenous variables like the federal excise tax credits and other policies on the future of biodiesel
- The potential for increased nitrogen oxides (NOx) emissions and engine contamination are both discussed and suggestions to mitigate these concerns are drawn from the literature

The last chapter of the report provides a set of proposals over three phases for WOTRC actions to bring biodiesel to the community to reduce diesel pollution.

1. Biodiesel Production and Emission Chemistry

2.1 The Science behind Biodiesel

Four ways to make biodiesel:

1) Direct use and blending

2) Micro emulsions

3) Thermal cracking (pyrolysis)

4) Transesterification[1]

Transesterification is the most commonly used method to produce biodiesel from vegetable oils and animal fats. It is the reaction of a fat or oil with an alcohol to form esters and the by-product glycerol, also referred to as glycerin (Krahl et al 1994). A catalyst is usually used to improve the reaction rate and yield. Because the reaction is reversible, excess alcohol, typically methanol or ethanol is used to shift the equilibrium to the products side (Krahl et al 1994). The chemical reaction is shown in Fig. 2.1.

Production of biodiesel requires lowering the viscosity so that the fuel can flow well (Krahl et al 1994). Other production methods also lower the viscosity; however, transesterification is the only method that does not cause engine performance problems, such as carbon deposit and lubricating oil contamination (Ma et al 1999). Transesterification lowers the viscosity or resistance to flow of the oil or fat, because it does not adversely affect the engine when the final product is used.

Fig. 2.1 Transesterification Chemical Reactions

CH2-OOC-R1				R1-COO-R’		CH2-OH
|			Catalyst			
CH-OOC-R2	+	3R’OH	$\rightleftarrows$	R2-COO-R’	+	CH-OH
|						
CH-OOC-R1				R3-COO-R’		CH2-OH
Glyceride		**Alcohol**		**Esters**		**Glycerol**

Source: Biodiesel Production: A Review

Fig. 2.1 Displays the alcohol and glyceride reaction with a catalyst which yields a methyl ester and glycerol by-product.

2.2 Emission Chemistry

Biodiesel can be produced from multiple feedstocks like waste grease, animal fats, or fuels such as soy oil. The emissions characteristics are based on the chemical structure of the individual feedstock. This requires understanding the chemical structure of a fat or oil.

Chemical Structure of Biodiesel

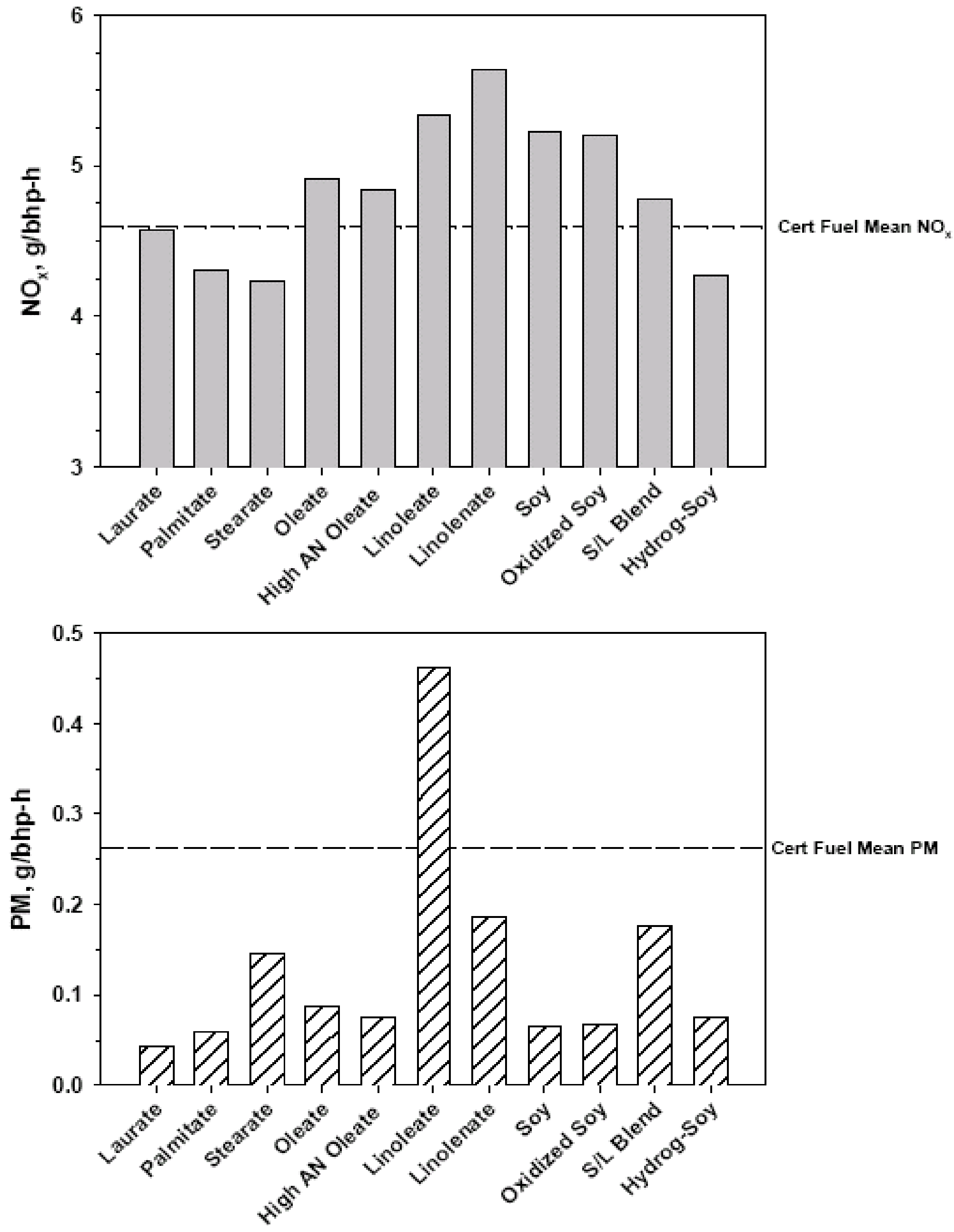
- Each fat or oil molecule is made up of a glycerin backbone with three carbons, and on each of these carbons is attached a long chain fatty acid.
- These long chain fatty acids are what react with methanol to make the methyl ester, or biodiesel.
- The glycerin backbone is turned into glycerin and sold as a byproduct of biodiesel manufacturing.

Krahl et al 1999

While biodiesel chemistry is entirely more intricate (Krahl et al 1994) illustrates the fact that most fats and oils contain 10 types of common fatty acids which have between 12 and 22 carbon atoms, with over 90% of them being between 16 and 18 carbon atoms (Krahl et al 1994). The number of carbon atoms is important because these fatty acid chains have various numbers of olefinic or double bonds made of carbon atoms that compose the fatty acid chains. The number of olefinic (double) bonds depends on the number of carbon atoms. Some of these fatty acid chains are saturated (no double bonds), while others are monounsaturated (single double bond) and others are polyunsaturated (multiple double bonds) (Lendvay, 2006). Differing levels of saturation can affect the biodiesel fuel properties, and fuel properties are directly related to emissions (McCormick et al 2003). Therefore the entire connection begins with chemical properties, which determine fuel properties that in turn characterize emissions. Fuel properties will be addressed later in the NOx Assessment (Section 6). This section focuses specifically on the emissions of two criteria pollutants, Nitrous Oxides (NOx) and Particulate Matter (PM), to elucidate the relationship between chemical structure and emissions. The emissions analysis explains the chemical structure and related emissions of various feedstocks.

Individual feedstocks have unique chemical structures that differ by number of carbon bonds which affect emissions characteristics. Again, a different structure translates to different emissions. For instance, a relationship between double bonds and NOx has been found. One example is stearate based fuels that are saturated so they have no double bonds, and produce significantly less NOx than certification diesel, or the diesel currently used in most diesel burning engines (McCormick et al 2003). The same concept is depicted in Fig. 2.2. These graphics display the NOx and PM emissions from seven different methyl esters, or 100% biodiesel fuels produced from seven feedstocks. Of those seven, methyl palmitate, methyl laurate, methyl stearate, and hydrogenated-soy all produced less NOx than certification diesel, while only methyl linoleate produced higher PM. It is important to keep in mind these emissions differ by specific chemical structure (McCormick et al 2003). Now that it is understood that chemical structure impacts biodiesel emissions, the next step is to take a look at the numerous sources where combustion actually takes place. Calculating the petroleum diesel emissions using the goods movement approach, and comparing those emissions with biodiesel emissions provides an estimate of the emissions reductions that biodiesel can achieve in West Oakland.

Fig. 2.2



Source: The Effect of Biodiesel Composition on Engine Emissions from a DDC Series 60 Diesel Engine, Graboski et al 2003

Fig. 2.2 compares PM and NOx emissions from seven different methyl esters with California certification fuel. In this test, methyl palmitate, methyl stearate, and hydrogenated soy all produced less NOx emissions than the certification fuel.

2.3 The Goods Movement Approach and Emissions

The goods movement approach in this section determines the diesel emissions from imports and exports that pass through the Port of Oakland. Consider the following example to help explain the goods movement process. A pair of shorts is made in a Chinese factory. These shorts are boxed along with a sum of other shorts and put on a diesel truck. This truck travels to one of the major ports in China. Chances are the shorts end up in either Shanghai or Hong Kong. The shorts are put on a ship that comes to a major port on the West Coast. Once it reaches any one of the major West Coast ports, the shorts may be shipped to a number of places. Case in point, if the shorts stay in a 400 mile radius they are typically put on a diesel truck and driven to their final destination. Rail is used if the shorts are going farther than 400 miles (Whittington, 2006). Essentially, from the point the pair of shorts is manufactured to the point the pair of shorts is put on the shelves of the department store it goes through a series of transportation modes. This series is goods movement. From the marine vessels that ship the goods to the forklifts that unload them, almost every engine in this process uses diesel fuel. The goods movement approach was used to calculate the diesel emissions in West Oakland because a substantial portion of the diesel emissions in West Oakland can be attributed to imports and exports, or goods movement. The following passage from Environmental Health Perspectives Journal provides a broad overview of pollution associated with the goods movement.

Environmental Health Perspectives by Andrea Hricko, 2005.

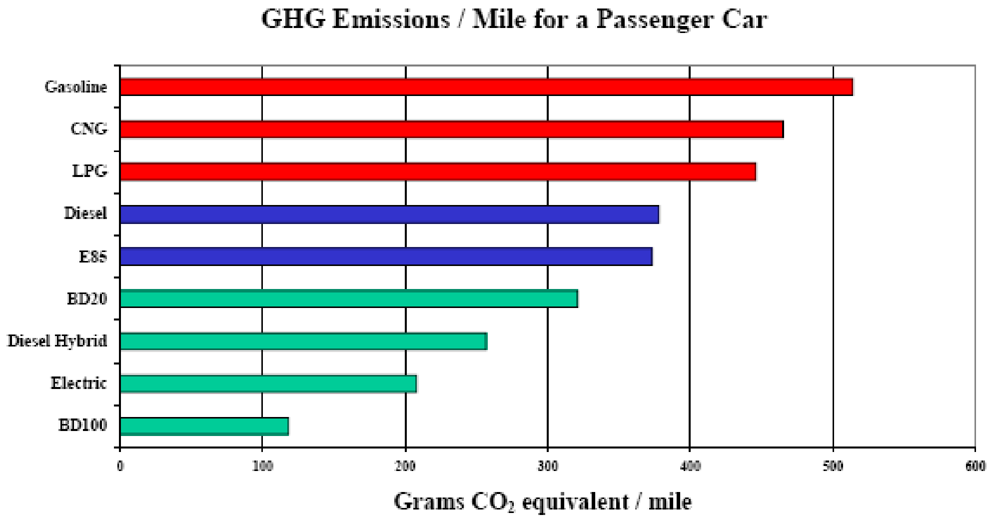
The Ports of LA and Long Beach are responsible for 128 tons of diesel PM emissions daily. This is approximately 21% of the total diesel PM emissions in the South Coast Air Basin, an area that includes Orange County and portions of Los Angeles, Riverside, and San Bernardino counties. Of this, 73% was emitted by ships in coastal waters extending 14 to 100 miles offshore from California, while commercial harbor craft accounted for 14% of the total. Other sources were cargo handling equipment (10%), in-port heavy-duty trucks (2%), and in-port locomotives (1%).

Ships are obviously big culprits of emissions. The remaining 13% of emissions still translates to 33,280 pounds of PM per day emitted at the Ports of LA and Long Beach. On the other hand, the Port of Oakland handles about 1/5 of the combined container traffic flowing through the Ports of LA and Long Beach[2]. The Port of Oakland is, however, expected to expand vastly. An Oakland tribune article entitled *Oakland's Ports grows faster than any other on West Coast,* published January 24, 2006, noted Oakland's port grew more rampant than both LA and Long Beach ports, increasing container throughput 20%. Ezra Finkin is a legislative director of the Washington, D.C.-based Waterfront Coalition, and a lobbying firm that represents shippers. In the same Oakland Tribune article he is quoted as saying, "Oakland is becoming a major container gateway. Importers are looking for alternative(s)." China is drastically increasing exports, and the congested infrastructure at Southern California ports is diverting imports, making Oakland the alternative. Port growth translates to more port associated traffic and subsequent emissions, obviating the environmental adversities associated with the goods movement. In a recent statement International Longshore and Warehouse Union (ILWU) President James Spinosa said the ILWU aims to cut emissions from diesel-fueled vessels calling at West Coast ports 20% by2010 and to reduce pollution from trucks and cargo-handling equipment on the docks[3]. This is one of many initiatives to reduce pollution associated with the goods movement. The Ports of LA and Shanghai also have letters of intention to reduce air pollution (www.portoflosangeles.org, 2006). As ports around the nation and the globe comprehend the need for an alternative to diesel, they look to biodiesel to reduce emissions. One Port is leading the way. The Port of Seattle has already signed a contract to purchase almost 1 million gallons of biodiesel from Seattle Biodiesel[4]. The specific emissions reductions that biodiesel can achieve at the Port of Oakland are laid out in the following section.

2.4 Reducing Particulate Matter and Carbon Monoxide at the Port of Oakland with Biodiesel

Displacing conventional diesel with biodiesel yields immediate local emissions reductions. Biodiesel burns cleanly and reduces toxic air pollutants[5]. The emissions reductions include, but are not limited to, carcinogenic diesel particulate matter (PM), carbon monoxide (CO), sulfates, and hydrocarbon (HC) emissions. The Port of Oakland has stringent goals based around emissions reductions. Among other options to reach these goals, biodiesel can help by reducing many diesel related emissions. For instance, a splash blend of 20% biodiesel (B20) reduces sulfates and hydrocarbons by 21%, CO and PM approximately 10%, and ozone precursors 10%. Even more significant, 100% biodiesel (B100) can reduce Hydrocarbons by 69%, and CO and PM emissions approximately 40%[6]. Fig. 2.3 displays the greenhouse gas (GHG) emissions per mile for a passenger car. B100 emits the least amount of GHGs per mile in a passenger car.

Fig. 2.3

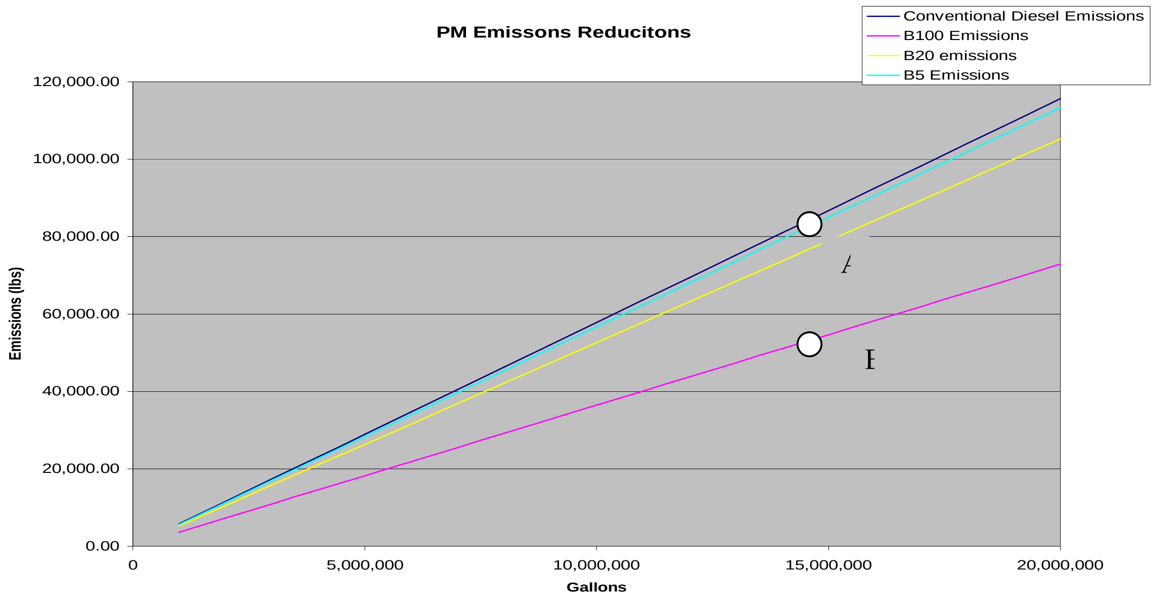


Source: Harvard Report:http://www.biofuels.coop/archive/harvard_biodiesel.pdf

Fig. 2.3 compares the Greenhouse Gas Emissions with natural gas diesel, ethanol and gas blends, and even diesel hybrid. 100% biodiesel emits the least amount of greenhouse gases.

Fig. 2.4 displays PM and CO emissions for certification diesel, B5, B20, and B100 biodiesel at uses that range from 0 to 20 million (mm) gallons. These two pollutants are the focus of this section because PM is a major cause of lung problems, and reducing carbon is a priority to reduce global warming. Each blend above is represented correspondingly in descending order on the graph. (Certification diesel then B5, B20, and B100). Since it will take some time to completely convert to biodiesel at the Port of Oakland these charts can be used to determine how much emissions will be reduced, depending on the amount of biodiesel that is used and the blend[7]**.** This chart is a great tool to plan ramping up in accordance with setting emissions goals. The following section is a market analysis that illustrates the past use, or past biodiesel market, in the U.S., as well as the potential for biodiesel to be used in diesel burning engines in West Oakland. The market analysis is a significant indicator of trends in biodiesel.

Fig. 2.4



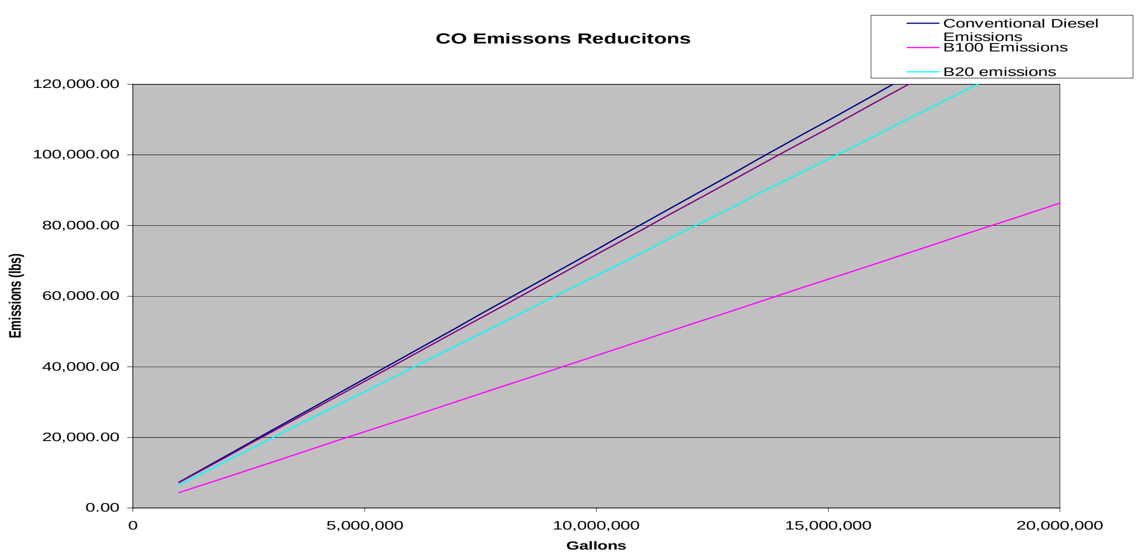


Fig. 2.4 displays PM and CO emissions for certification diesel, B5, B20, and B100 biodiesel at uses that range from 0 to 20 mm gallons. Each blend above is represented correspondingly in descending order on the graph. (Certification diesel is on the top, then B5, B20, and B100). Point A on the PM graph equals the emissions of using about 15 million gallons of B20 (80,000 lbs) , whereas, point B equals the emissions of B100 (50,000 lbs). The benefit from going to B100 from B20 is 30,000 pounds of PM reductions for the given amount of time it takes to use 15 million gallons.

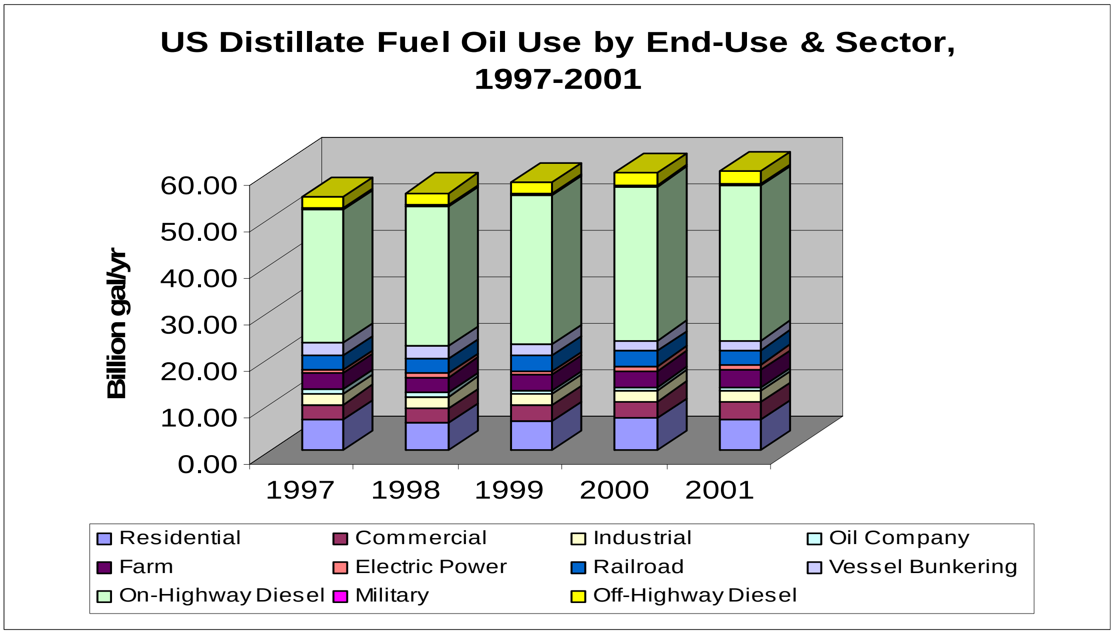
2. *Economic Analysis*

3.1 Biodiesel and Diesel Market

The feasibility of biodiesel will expand as the market infrastructure grows. Growth in use and supply ensures that biodiesel becomes more and more cost competitive with diesel. Furthermore, the more commercialized biodiesel becomes, the more systematic the use and distribution techniques will be. These are all trends we would hope to see if biodiesel is adopted in West Oakland, because it proves the credibility and the availability of the fuel. The past trend in the biodiesel market shows 131% compound annual growth, expanding over 100-fold in only 5 years (www.nbb.org, 2006).

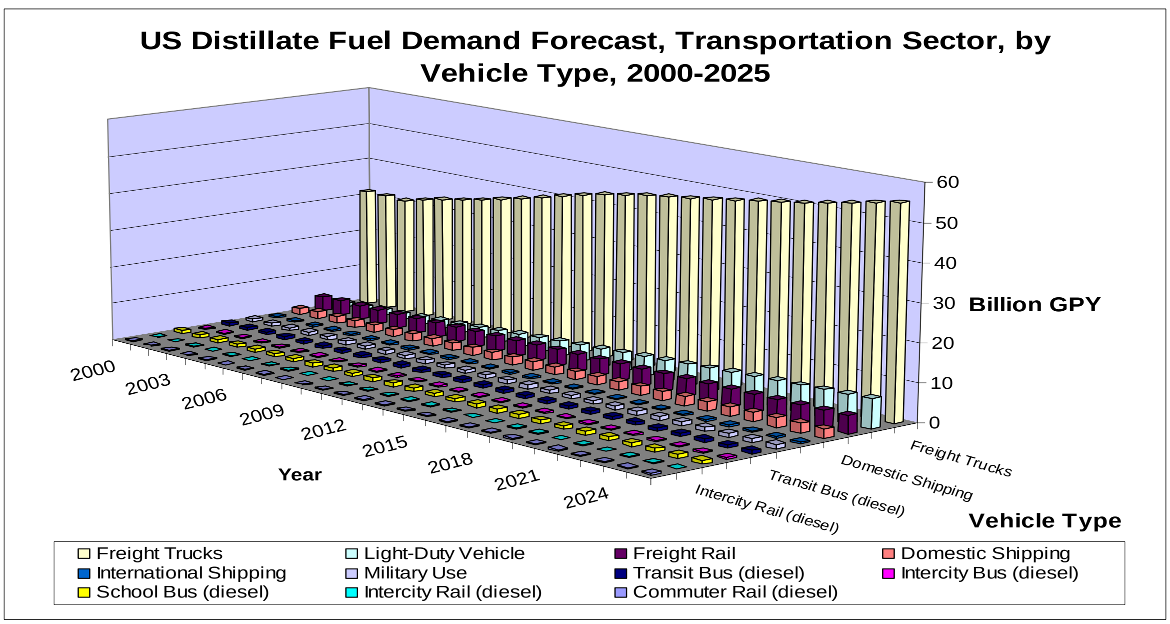
The biodiesel market is theoretically synonymous with the diesel market because engines that combust diesel can use biodiesel with little or no modification. The biodiesel market, however, is not that easy to identify. In fact there is the dilemma that while biodiesel can be burned in all diesel-using engines, it may not very well take over the entire diesel market. For example, we cannot simply wake up tomorrow and suggest every diesel user start using biodiesel. The discrepancy here is known as "market penetration." Market penetration takes time[8]. Therefore, to truly discuss the biodiesel market in the United States, and world wide, requires understanding the potential for biodiesel to permeate the diesel market, essentially one user at a time. Past trends in diesel end-use and forecasted diesel end-use are two points to begin investigating the propensity of diesel users to convert to biodiesel or biodiesel blends. In other words, if we know who is using the diesel, we know who the potential users of biodiesel are, and how likely they are to use biodiesel.

Fig. 3.1



Source: (Duff , 2004)

Fig. 3.2



Source: (Duff , 2004)

Fig. 3.1 shows U.S. distillate fuel demand between 1997 and 2001 by sector. Fig. 3.2 shows U.S. distillate fuel demand forecast through 2025 in billions of gallons.

Fig. 3.1 shows U.S. distillate[9] fuel demand between 1997 and 2001 was driven principally by on-highway diesel consumption, totaling more than the other ten major sectors combined every year. Fig. 3.2 suggests on-highway diesel consumption will grow approximately 20 billion gallons annually, reaching nearly 55 billion gallons per year in 2024. The past consumption and forecasted growth of on-highway diesel clearly demonstrates that on highway diesel use will continue to be the largest consumer of domestic diesel. Heavy-Duty Vehicles (HDV's), such as diesel trucks categorize most of this on-highway diesel. This is important because HDV's have expressed the recent propensity to use biodiesel. Since HDV's are a large constituent of on highway diesel, and on highway diesel is by far the largest use of diesel, we can assess whether biodiesel will penetrate the diesel market in the future. According to the past data, the recent adoption of biodiesel by HDV's suggests biodiesel use will continue to grow. For example, the National Biodiesel Board (NBB) conducted an end-user survey. The average fleet was 550 diesel powered-vehicles, and the survey reported that of 45% of surveyed end users were favorable users of biodiesel (www.nbb.org, 2006). Another example of HDV's recent adoption of biodiesel comes from the Department of Energy (DOE). The DOE reported fleets complied with Energy Policy Act of 1992 (EPACT) fleet provisions[10] by purchasing 2.2 million gallons of biodiesel and using a record number of 1,474 biodiesel credits. Furthermore, the DOE noted that fleet use of biodiesel expanded from 60 to 77 fleets, within the group of EPACT participants (www.doe.gov, 2006). Projections by the Energy Information Administration (EIA) reaffirm the market expansion of biodiesel. Fig. 3.5 represents high bound projections for biodiesel from the EIA. The EIA anticipates the biodiesel market will expand to 475 mm gallons by 2010 from about 75 million gallons in 2005 (www.nbb.org, 2006). This translates to a compound annual growth rate (CAGR) of 45%, over five-fold growth. The NBB survey, DOE reports, and EIA forecasts are constructive trends that suggest biodiesel will permeate a substantial portion of the diesel market. Again this is important to West Oakland, because market expansion of biodiesel suggests that biodiesel will continue to be a reliable alternative to diesel. Despite the recent trends in biodiesel use, the fact it has mostly been in the Midwest does pose uncertainty for the West Coast.

3.2 US Biodiesel Market vs. California Biodiesel Market

There is an immense amount of buzz around the biofuels market in the investment sector. According to a Clean Edge report, biofuels exceeded both wind and solar in 2005 worldwide investment will grow from $15.7 billion in 2005 to $52.5 billion by 2015 (www.cleanedge.com, 2006). Yet, the rapid growth in the U.S. biodiesel market has been mostly in the east, creating uncertainties in the future of biodiesel on the West Coast.

Fig. 3.3 and Fig. 3.4 are maps from the National Biodiesel Board. Fig. 3.3 displays biodiesel distribution, or retail sites, and Fig. 3.4 shows biodiesel production locations. Biodiesel production and distribution has been primarily in the Midwestern U.S., as opposed to the West Coast. There is a reason for this asymmetry. It is due to the proximity of "virgin" feedstock. Soybean is a major crop grown in the Midwest and soy oil, made from crushed soy beans, is the "virgin" feedstock used for most biodiesel production in the nation. Indiana and Illinois, for example, are large soy bean producers and have over 100 retailers in each state compared to approximately 18 retailers in California (www.indianafarmdirect.com, 2006). This translates to a density discrepancy between California and the Midwest states which inherently creates an impediment for biodiesel use in California. To illustrate this point take the density of retailers in Indiana. There is a biodiesel retailer almost every 300 square miles. Conversely, in California, there is sparsely one every 10,000 square miles. Now compare that to oil refineries and gas stations. In 2001 there were about 20 petroleum refineries, and over 66,000 gas stations in the State of California. That is one gas station every 2 and half square miles. Truly getting biodiesel used in California, and specifically in West Oakland, requires that large-scale biodiesel distribution enter the Bay Area.

Fig. 3.3: U.S. Biodiesel Distribution

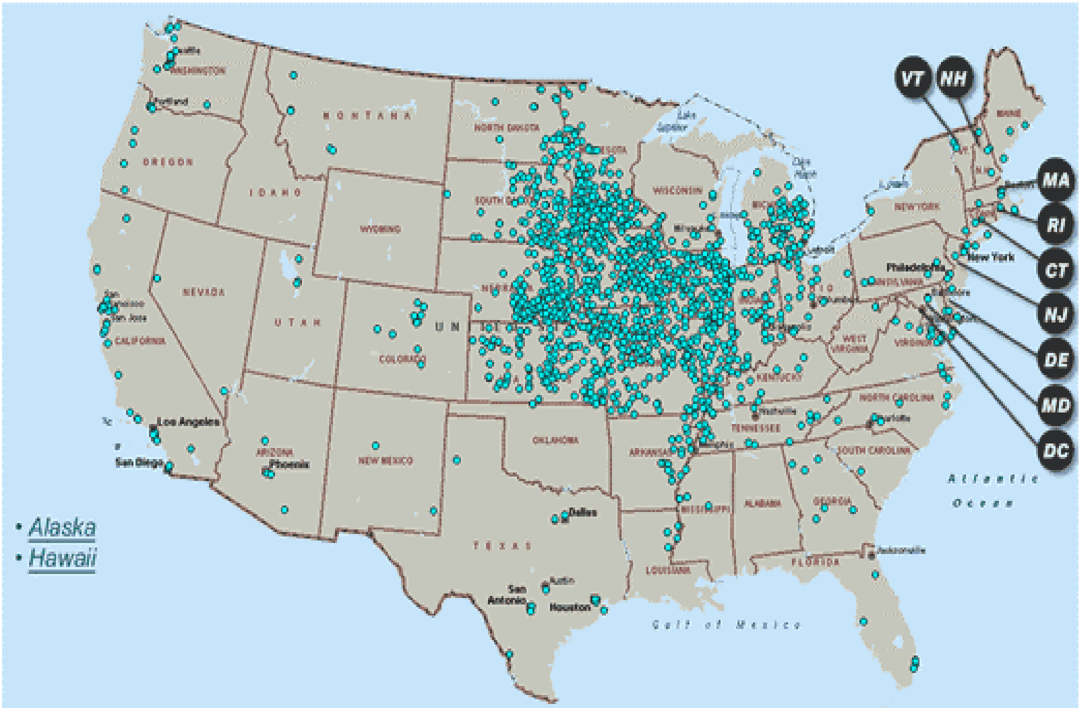
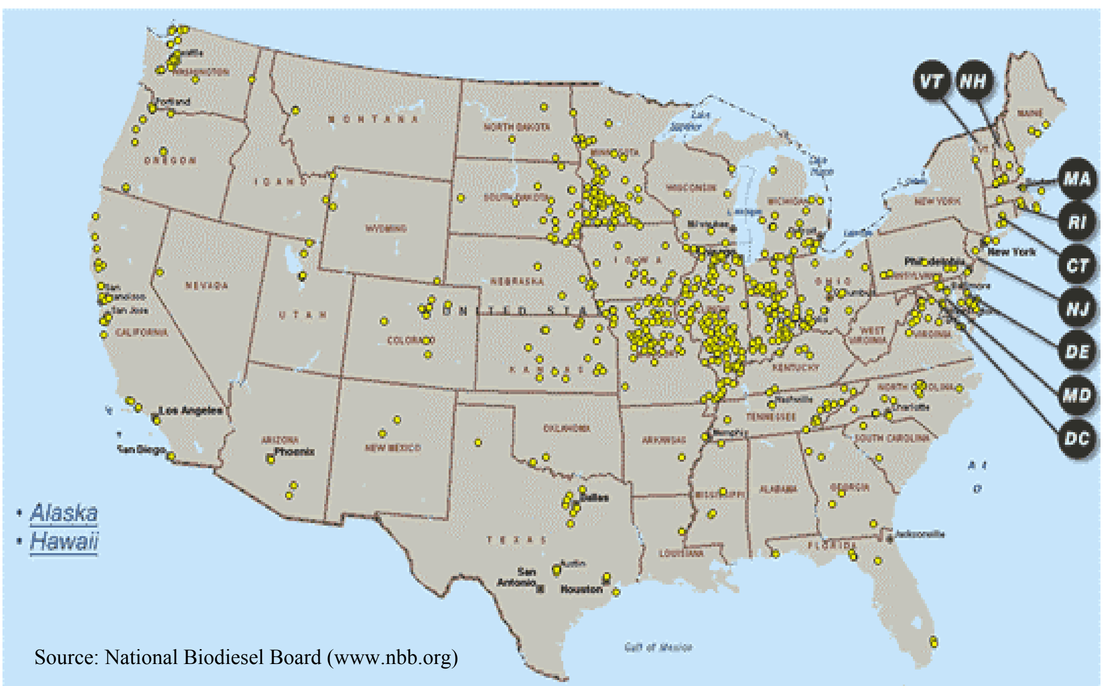


Fig. 3.4: U.S. Biodiesel Production



Source: National Biodiesel Board (www.nbb.org)

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Biodiesel production can in fact expand in California. There is already large scale production and distribution. However, a powerful, regulatory climate will stimulate the market to grow. It seems that production in the Bay Area is just a matter of when not if. A regulatory climate is being developed through subsidies to produce biodiesel, incentives to use biodiesel, and even rules that complement the use of biodiesel. The following are examples of regulations that have the potential to expand the biodiesel market in California. First, Congress has recently extended the federal excise tax credit through 2008, which is partially responsible for the amazing growth so far. Second, EPACT is setting records in biodiesel use. Third, the EIA forecasts that the ultra-low sulfur diesel (ULSD) rules will influence high growth rates (Fig 3.5). ULSD removes sulfur, and subsequently lubricity, which is replaced by biodiesel in blends as low as 2% biodiesel (www.nbb.org, 2006). Lastly, is perhaps one of the most important initiatives for the West Coast. The EPA has made the industry aware of the new objectives to reduce diesel emissions with grants totaling over $1.4 million and leveraging an additional $5.8 million in matching funds through the West Coast Toxics Reduction Collaborative (WCTRC) (www.Westcoastdiesel.org, 2006).

Fig. 3.5

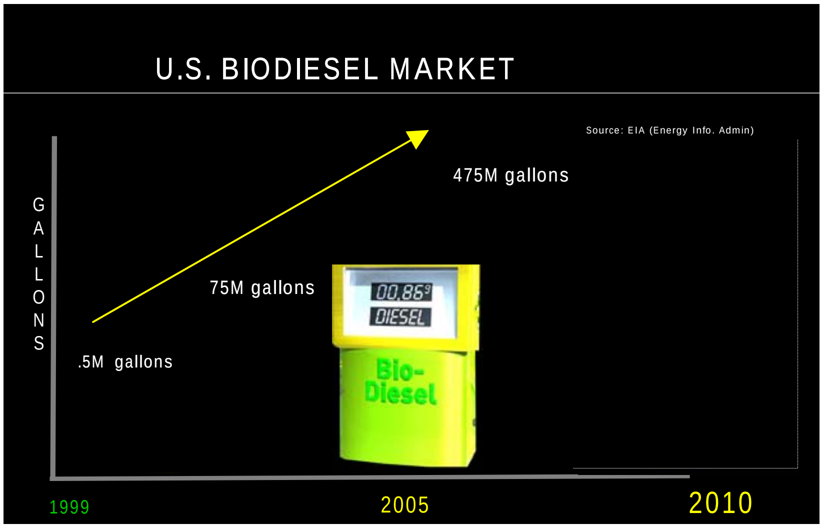


Fig. 3.5 is past and forecasted growth in the U.S. biodiesel market. From 1999 to 2005 the compound annual growth rates was 131%, and from 2005 to 2010 (EIA high-bound forecast based on ULSD rule in effect) the compound annual growth rate is 45%. Each rate reflects significant growth.

3. Microeconomic Analysis: Bay Area Supply and West Oakland Demand

4.1 West Oakland Diesel Demand

The following section proves the market for biodiesel in West Oakland. There should be no doubt about the massive size of the diesel demand in West Oakland. Thousands of trucks enter the community every day, but they are not the only sources of emissions. Terminals at the Port of Oakland use millions of gallons of diesel per year. This does not include the entourage of marine vessels entering the port on an annual basis. According to *America's Ports Today*, a February 2006 brief from the American Association of Port Authorities, U.S. ports and waterways move almost 99% of the country's international trade by volume, and the U.S. cargo volume[11] is expected to double over the next 15 years.

In a previous section, the goods movement approach was used to estimate emissions. Those emissions are based on a speculative range of diesel use at the Port of Oakland. Therefore the same approach is used to determine demand for diesel at the Port of Oakland. The Port of Oakland is a substantial, centralized constituent of Oakland diesel demand. This means it is a very large target market for biodiesel. The port process is a good vantage point to calculate demand. Since it is a landlord port, the marine terminals at the Port of Oakland are owned by shipping lines who outsource terminal operations. Terminal operators purchase fuel for all the equipment in a single terminal. There are approximately 11 terminals in the Port of Oakland, varying by size and fuel use. The typical vessel enters the port where the containers aboard the ship are unloaded via an electric crane on to a diesel hostler. The hostler then ushers the container over to a large diesel forklift, which puts the container on a diesel truck that takes the container to its destination (Leong, 2006). Over 2 million Twenty-foot Equivalent Units (TEU) were trafficked through the Port of Oakland last year. Due to traffic issues diverting imports from L.A. and Long Beach, and now that Oakland has increased capacity, Oakland's container traffic is expected to double sometime in the near future (Whittington, 2006).

Port Equipment*	**total equip per port**	**miles per day/equip**	gallon per year
Generators*	**400**	**-**	**3,960,000.00**
Forklifts	**400**	**12**	**480,000.00**
Hosteler	**460**	**12**	**552,000.00**
Other mobile equip	**340**	**12**	
Total gallons for port equipment	**4,992,000.00***		

*Trucks not included in this Table. *Generators are used to support ship electricity.

Calculating the exact demand for diesel demand at the Port of Oakland was challenging. There are no data for specific terminal equipment numbers. So the conservative estimate is based on the number of hostlers, forklifts, diesel trucks, generators, and a category for other mobile equipment at the port only. The estimation does not include city vehicles, postal service vehicles, or other trucks traveling in and out of West Oakland not associated with the port.

Diesel Trucks

The port demand model for this report assumes that 80% of the 2000 port oriented trucks are local short hauls who run from the port to the rail yard, with an average round trip length of 1 mile, and have a fuel economy of 2 miles per gallon. The remaining 20% of trucks are calculated with average trip lengths of 100 miles per day, but only filling up locally 50% of the time, with an average fuel economy of 7 miles per gallon because they travel on-highway.

Port Equipment and Tugboats

Some larger port terminals need more equipment whereas smaller terminals use less (Leong, 2006) Therefore, two categories were used to estimate the equipment at 11 port terminals. Each type of equipment, except generators, was estimated to travel 6 miles per day on average. Mileage was estimated at 3 miles per gallon for each mobile piece. In addition to Port terminal equipment, the model assumes 50 tugboats use 75 gallons each per day. The annual was estimated at 330 days in a year to be conservative. A high estimate was calculated by increasing the number of generators, the number of tugboats, and the number of miles for each piece of port equipment; and long and short haul truck trips in one day. The result was on average 10 million gallons per year, with a low estimate of 5 million gallons per year and a high estimate of 17 million per year.

4.2 Other Considerations to Calculate Demand

Marine vessels and the Postal Service equipment were not included in this estimate. In 2000, residents in West Oakland set out to conduct a survey on truck trips in their community. What they found was astonishing. Out of a total 2,491total trucks trips per day in West Oakland, the U.S. Postal Service equipment make 947 trips. In addition the port hosts 1,902 marine vessels annually[12] and each vessel holds approximately nine tons[13] of fuel. If these vessels filled up at the Port of Oakland the fuel they use would increase the demand momentously. The demand just based around the Postal Service equipment and port-oriented trucks, and port equipment is enormous. Using biodiesel in some of these places could drastically reduce diesel pollution. However, biodiesel is not readily available in West Oakland like it is in the Midwest. So the question of where to actually obtain biodiesel still remains.

4.3 West Oakland Diesel and Biodiesel Supply

Whereas diesel is delivered or supplied at gas stations, biodiesel is not as readily available. According the National Biodiesel Board there is an estimated 13 producers in Northern California; however, when contact was attempted, approximately 25% were not distributing biodiesel on a consistent basis. I did manage to speak with two non-producing distributors; SF Petroleum and Cross Petroleum. During an interview in winter 2006, a SF Petroleum representative stated the company was in the process of contracting to supply the City of San Francisco. According to these interviews, retailers or distributors can acquire biodiesel through 3 primary sources.

1) Local Oil Companies acquire large loads of biodiesel from the Midwest and deliver to smaller distributors but do not produce biodiesel. For example, Cross Petroleum of Mt. Shasta California said that virgin biodiesel is delivered for as cheap as $2.25 per gallon in this process (Cross, 2006).
2) Fuel can be a purchased from California producers, who produce mostly in South California (Wright, 2006).
3) Retailers can purchase from large-scale producers from around the nation.

The retailer/distributor, or producer of biodiesel can help bridge the gap between biodiesel and diesel use. If it is not middle-manned through a distributor it comes directly from the producer in the Midwest. Rail costs approximately an additional 10 cents per gallon, and freight on a truck is around 20 cents per gallon when importing soy oil (Maese, 2006). In essence, the consumer gets biodiesel from the distributor/retailer or the producer. Currently, there are no options in San Francisco or Oakland to pump biodiesel into HDV's. The BioFuel Oasis in Berkeley, CA has the only pumps in Alameda County. However, they do not sell lower level blends and service mostly passenger cars (Radtke, 2006). This supply chain creates a problem for large scale users such as port terminals. Since there are no large producers, the fuel is not readily available, making the user go out of the way to have it delivered and stored in large tanks. The upside for biodiesel in West Oakland is it can be a profitable business, and there are many looking to begin large-scale production in West Oakland. So where do these producers get the supply of their feedstock? Soy oil and waste grease[14] are the two major options for feedstock supply in the Bay Area. Soy oil must be shipped in from the Midwest, consequently stifling profit margins. Waste grease, however, looks appealing for Bay Area biodiesel producers.

4.4 Waste Grease as a Potential Fuel Supply

The WOTRC set as a goal of the biodiesel initiative to "collect waste grease from local restaurants and convert it into biodiesel," (Fine, 2006). This is a great start to achieve a scale that dramatically reduces exposure to diesel PM and coinciding Hazardous Air Pollutants in West Oakland. However, biodiesel use in West Oakland must plan for scales needed to dramatically and significantly supplant current diesel uses, and consider the limitations surrounding waste grease. Before the limitations are discussed, it is important to lay out the process of converting waste grease to biodiesel and the supply of waste grease in the San Francisco Bay Area.

4.5 Waste Grease Collection and Filtration

Waste grease is collected in bins, which are provided to local restaurants, and other waste grease producers. Market research shows that the more streamlined the disposal process, the more successful the oil collection. Waste oil is transported from the collection site to onsite storage at the biodiesel production facility. At the facility the oil goes through pre-filtration, is treated with methanol during pre-acid treatment, and finally it goes into a dryer-separator before going into a reactor. This is the junction point where typical "virgin" oil feedstock would begin the

Fia. 4.1 Waste Grease Collection and Conversion to Biodiesel

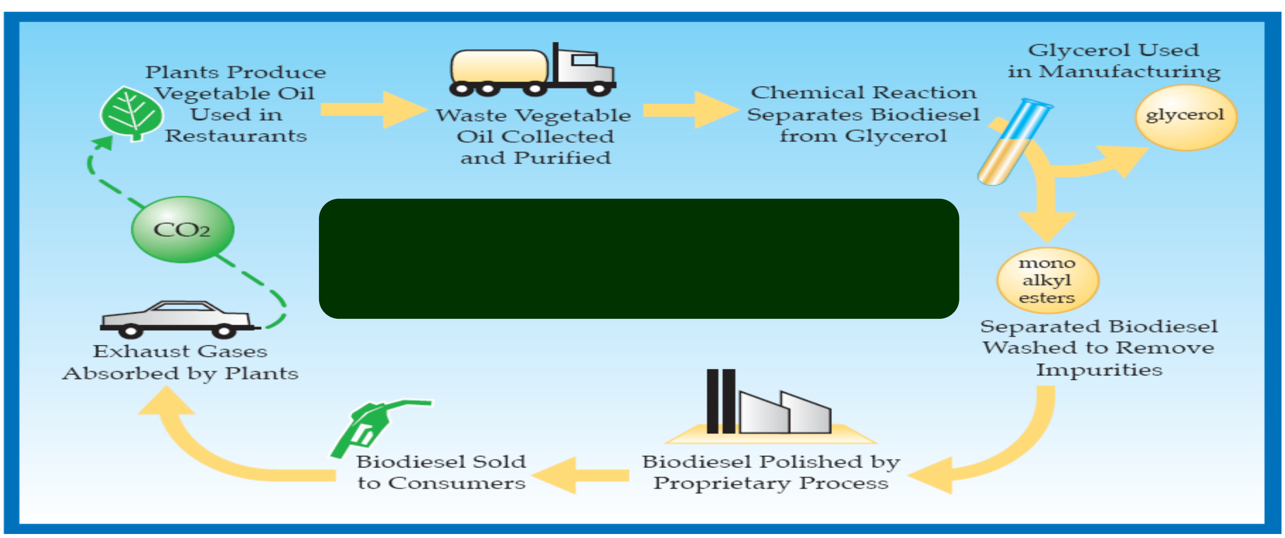


Fig. 4.1 shows the closed cycle of from waste grease based biodiesel production to the point where the fuel is sold and combusted and sequestered. From the top left the oil is collected from restaurants, reacted, processed, and sold. ***Source: Biodiesel of Las Vegas***

transesterification process. The rendering and production process is shown more in depth in Fig. 4.1.

4.6 San Francisco Bay Area Waste Grease Supply

An NREL Waste Grease Assessment in 1998 estimated pounds of waste grease per person per year (lbs/person/year). The study found, among thirty other metropolitan areas, that Sacramento produced 3.04 lbs/person/year; this Fig. was the lowest of the areas surveyed. The highest was 21 lbs/person/year in Lincoln, Nebraska. The weighted average was 8.47 lbs/person/year. Assuming 7.8 pounds per gallon of waste grease, using the population Fig. from 1990 in the San Francisco-Oakland-San Jose Area (approximately 6 million people), and 3.04 lbs/person/year, the San Francisco Bay Area metropolitan area produces over 18 million pounds, or 2.5 million gallons of waste grease per year. A high estimate uses the weighted average to calculate 58 million pounds, or 7.5 million gallons in all of the nine counties around the Bay Area. This estimate does not include trap grease. Trap grease in Sacramento was estimated to be 11 lbs/person/year; and the weighted average was 13 lbs/person/year. Trap grease is currently being collected at East Bay Municipal Utilities Department (EBMUD) who is evaluating opportunities for biodiesel production. The major impediment when using trap grease for biodiesel is decontamination. However, North American Biofuel Corporation has developed a proprietary method that commercially produces biodiesel from trap grease[15]. Fig. 4.2

highlights the counties with the most abundant amount of waste grease including Contra Costa, Alameda, and Santa Clara with 3.5 million gallons. Producers who locate in Alameda County will benefit from access to a large supply of waste grease very nearby (Wiltsee et al 1998).

Fig. 4.2

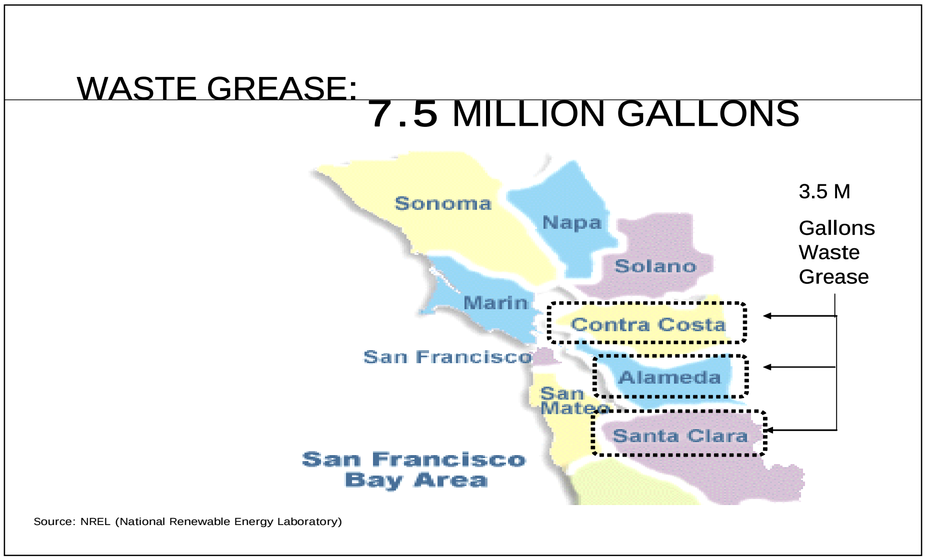


Fig. 4.2 highlights the counties with the most abundant amount of waste grease are Contra Costa, Alameda, and Santa Clara with 3.5 million gallons. Producers who locate in Alameda County will benefit from access to a large supply of waste grease very nearby.

Waste oil can provide a substantial portion of sustainable local production in West Oakland. For instance, the low estimate of diesel used at the port was close to 5 million gallons per year. To replace the low end port demand with B5 would require only 251,000 gallons of biodiesel. Assuming the ratio of waste grease to biodiesel is a little less than 1.5 to 1; producing 251,000 gallons of biodiesel requires 330,000 gallons of waste grease. To supplant this demand with B20 is requisite of 1 million gallons of biodiesel and approximately 1.3-1.5 million gallons of waste grease. The total high-end estimate for diesel at the Port of Oakland is nearly 17 million gallons per year. Judging by the high-end demand estimate; if the port operations switched to a B20 blend, it would require 4.5 million gallons of waste grease in the Bay Area. This amount is equal to about half of the high estimate of waste grease in the nine counties surrounding the Bay Area. Waste grease appears to be a feasible feedstock for, at least, a portion of the fuel demand at the Port of Oakland. At some point though, the uncertainties and limited supply will evoke the need for alternate sources of feedstock. The potential variance around the true number of gallons in the Bay Area should not go unnoticed. However, it would only require an estimated 1.12 million gallons of waste oil to supplant about 17 million gallons of conventional diesel with B5, making waste grease a good starting supply for producers.

Table 4.1

	Port Demand	Gallon of Biodiesel Needed for b5 Blend	Gallon of Biodiesel Needed for B20 Blend	Gallons GREASE needed to make B5	Gallons GREASE needed to make B20	total waste grease (Bay Area)
High	17,353,000	867,650	3,450,000	1,120,000	4,500,000	7.5 million gallons
Low	5,034,285.00	251,000	1,000,000	126,000	1,300,000	3.5 million gallons

Fig. 4.3

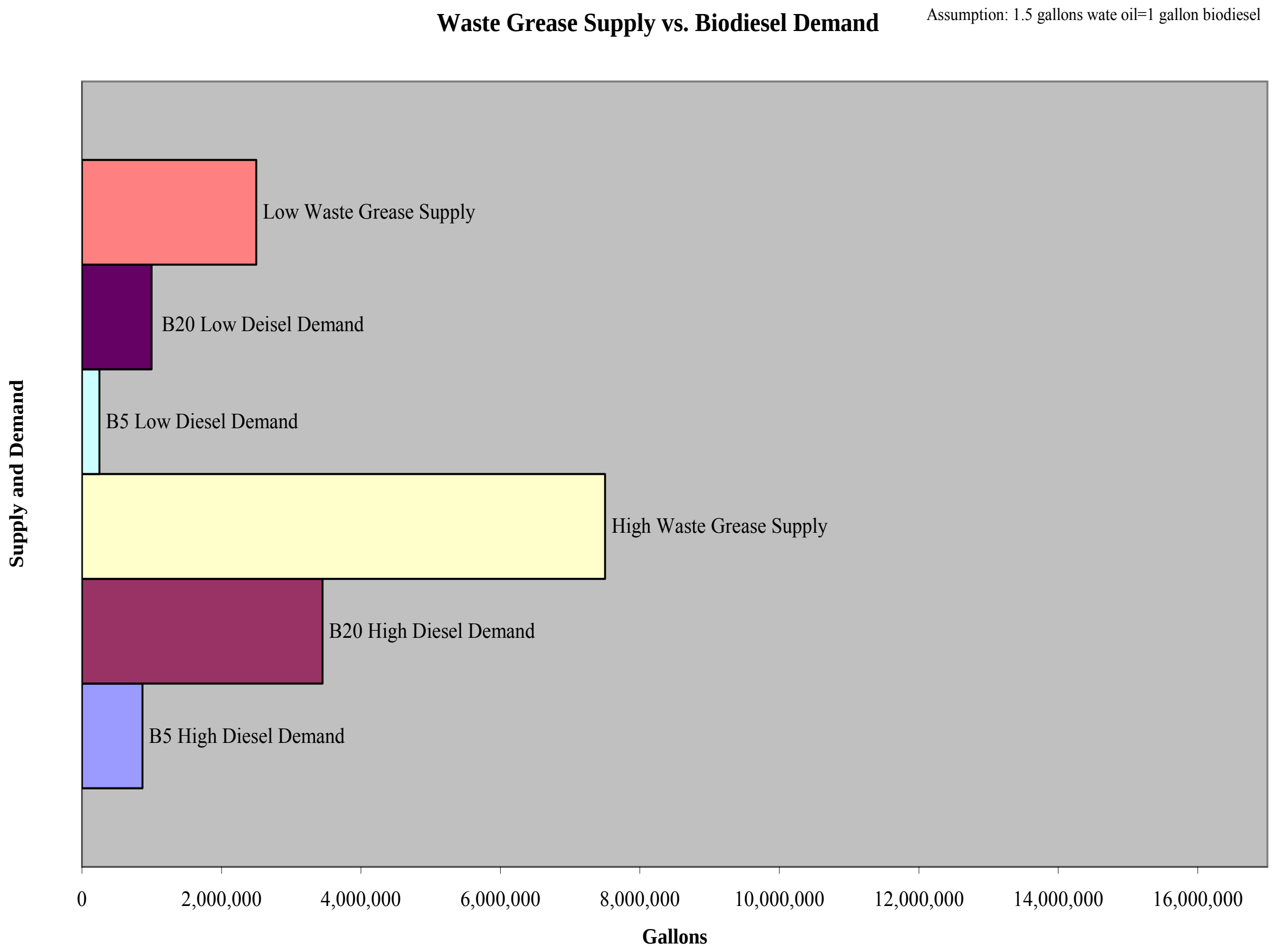


Table 4.1 and Fig. 4.3 assume 1.5 gallons of waste grease converts to 1 gallon of biodiesel. Each graphic compares waste grease and biodiesel demand to determine the amplitude of waste grease. The conservative diesel demand at the Port of Oakland was close to 5 million gallons per year. To replace the low end port demand with B5 would require only 251,000 gallon of biodiesel. Assuming the ratio of waste grease to biodiesel is a little less than 1.5 to 1 producing 251,000 gallons of biodiesel requires 330,000 gallons of waste grease. To supplant this demand with B20 is requisite of 1 million gallons of biodiesel and approximately 1.3-1.5 million gallons of waste grease.

The specific uncertainties of waste grease are based around total accessible supply, costs of filtration, collection, competition, short term contracts with suppliers, and the quality of the actual grease and the way it functions in engines. While waste oil commoditization and price volatility are discussed in ensuing sections, a few of the other major uncertainties are discussed in depth here. A hefty improbability is the quality of the waste grease when it is collected. For instance, the quality of the grease can be compromised on location before it is collected. These two characteristics result in the following disadvantages for waste grease:

Waste Grease Disadvantages:

- Difficult to process into biodiesel
- Biodiesel that gels quicker in cold temperatures(varies by production method)
- Often contaminated beyond use

(Wiltsee et al 1998)

In large, the feasibility of waste grease based-biodiesel depends on the receptivity of the locations that produce the waste grease. Therefore, waste grease market research was conducted to determine the propensity of large-scale waste grease producers to change collection service. This research was conducted by calling large producers of waste grease. The list included the Mascone Center, Shoreline Amphitheatre, UC Berkeley, Burger King, and even Norwegian Cruise Lines. Every single person interviewed said that price and reliability was central to their decision to contract with waste grease collectors. Furthermore, most companies stated that environmental benefits that biodiesel offers were important[16].

Nevertheless, biodiesel producers are in the position to offer very competitive prices because biodiesel is an incredibly profitable use for waste grease. Therefore the prices biodiesel producers charge for grease collection can under price the competition. Contracts for waste grease collection are not long term, so it makes it easy for biodiesel businesses to market to locations to change to their waste grease collection service (Wiltsee et al 1998).

4.7 Waste Grease Market Strategy: Barriers to Entry and Forming an Oligopoly

Strong business planning and collaboration between grease collectors can facilitate the availability of waste grease for biodiesel (Luatze, 2006). In early 2006, I contacted Steve Lautze, from the City of Oakland's Office of Economic Development, to get some insight on why he thought biodiesel production was not up and running in West Oakland, and what producers could do commence production using waste grease as a primary feedstock. Mr. Lautze suggested biodiesel producers need to have strong business planning, marketing, and contracting. Although good business practices are essential, collaboration between grease collectors is important to ensure that the local waste grease collection market only has a few biodiesel producers competing to prevent a price war. There is an economic concept based around competition called barriers to entry. Let's start with the concept of a monopoly to understand barriers to entry. A monopoly is a case where there is one market player. No other business can enter because of the player's barrier to entry. An oligopoly is similar to a monopoly. It has strong barriers to entry, but an oligopoly is formed between a few market players. The businesses in an oligopoly collaborate to stabilize prices in their market by minimizing competition, thus preventing a price war. A price war will inherently decrease the price grease suppliers, such as restaurants, pay for waste grease disposal (Louie, 2006). It is in the benefit of biodiesel producers, who also own a waste grease collection service, to establish an oligopoly around waste grease collection. Community officials may also be able to play a role in the formation of an oligopoly.

If the price that waste grease producers pay rapidly falls it can be called the commoditization of waste grease, and Ben Maese, from Biodiesel of Las Vegas, states waste grease is becoming recognized as a commodity. For example, the casinos in Las Vegas are charging for the collection of their grease (Maese, 2006) Nevertheless, waste grease can still be collected for a price in the Bay Area. Preventing the onset of commoditization of waste grease is essential for early biodiesel production in the Bay Area for three primary reasons:

1) Cheap feedstock can translate to cheap production.

2) Cheap production will allow for competitive prices.

3) Cheap production and competitive prices will ensure market development that will lead to economies of scale[17].

Currently, rendering companies collect waste grease and there are only a few of these companies in the Bay Area. These companies are a significant consideration when establishing an oligopoly in the waste grease collection market. More than likely some sort of agreement, or partnership is inevitable with these companies to minimize the price volatility in the waste grease market.

4. Production in West Oakland

5.1 Transesterification Methods

In the previous section on the science of biodiesel, the 4 ways to produce biodiesel were discussed. To recap, transesterification is the most common method to lower viscosity, or flow of the fuel. (Ma et al 1999) discuss in detail the three basic chemical transesterification methods to produce methyl esters from renewable oils and fats. Any of these routes can be continuous or batch[18]. Continuous process generally yields higher rates of production and therefore is used at higher production capacity plants. On the other hand, batch processing is slower and used for levels of production below 10 mm gallons per year (Ma et al 1999). A continuous transesterification process is shown in Fig. 5.1. A batch process is shown in Fig. 5.2. A producer must choose their production method accordingly; this is typically based on collaboration between the owner and the production technician.

Three Transesterification Methods:

1) Base catalyzed transesterification of oil with methanol.
2) Direct acid catalyzed esterfication of oil with methanol.
3) Conversion of the oil to fatty acids, and then to methyl esters with acid catalysis.

Fig. 5.1 Continuous Transesterification Process

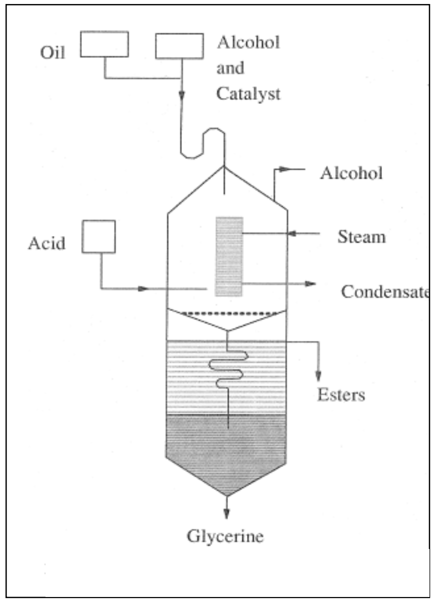
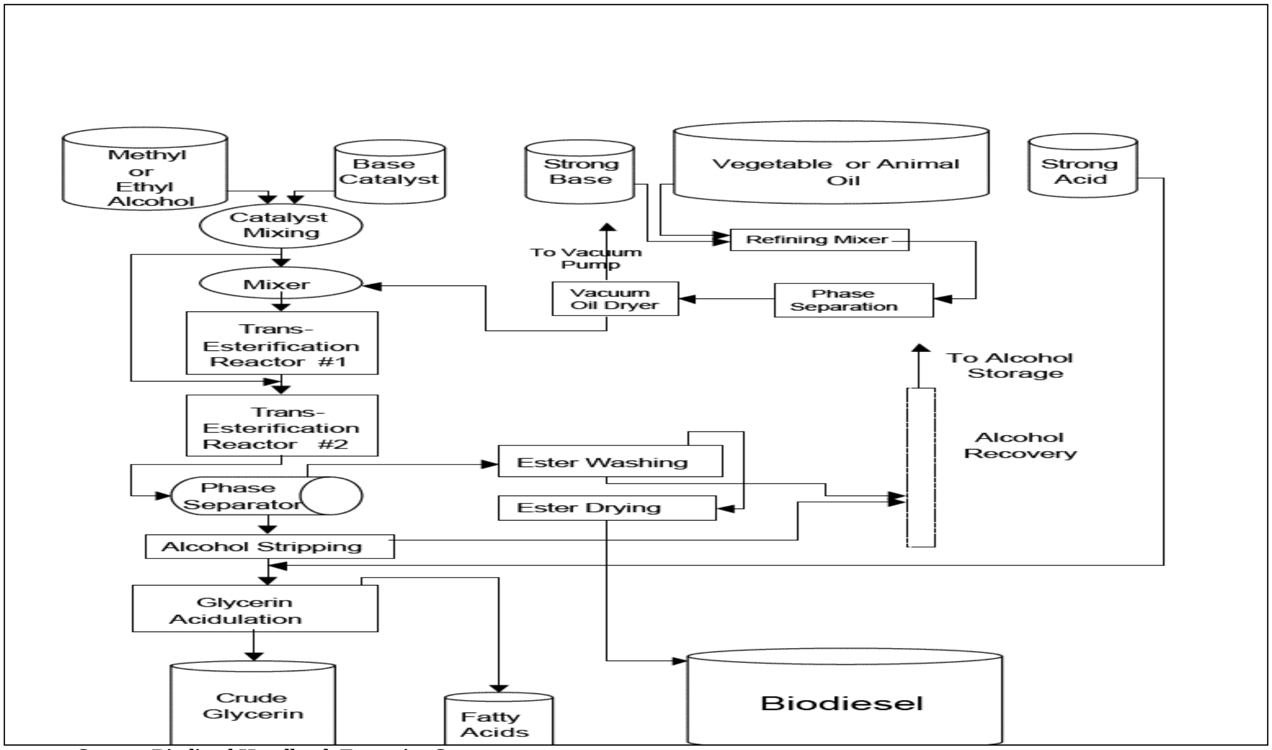


Fig. 5.1 is a picture of a continuous transesterification process. The process begins with the oil which is mixed with alcohol and catalyst. During this process glycerin is produced and the alcohol can be reclaimed *(Ma et al 1999).*

Annual capacity, feedstock type, and desired flexibility between feedstocks are factors that affect the exact technology selected for production. Biodiesel production has recently become more competitive and many outfits currently distinguish themselves on proprietary methods of production (Tong, 2006). For instance, Castor & Pollux claim their method exceeds 99% efficiency, and Seattle Biodiesel asserts their proprietary method is one of the fastest on the market, and produces fuel with the longest shelf life (www.seattlebiodiesel.com, 2006). Efficient and innovative technology can generate quick success for a biodiesel production outfit because it creates a significant barrier against other producers who wish to enter market. Although it is not patented, the proprietary production technique of Seattle Biodiesel was one element of the business that influenced venture funding from firms such as Nth Power Venture Capital for over $7 million, demonstrating the benefit to having such technology (Tong, 2006).

Fig. 5.2 Batch Transesterification Process



Source: Biodiesel Handbook Executive Summary

Fig. 5.2 is a picture of a batch transesterification process. The process begins with the oil which is mixed with alcohol and catalyst. This process uses multiple reactors as opposed to continuous flow which uses one. Like in continuous processing, during this process glycerin is produced and the alcohol can be reclaimed. However the exact percent may be different for each process.

5.2 Biodiesel Capital Inputs

This section takes a microeconomic approach to assess the dimensions of an individual production plant in West Oakland. Table 5.1 displays the general inputs of a 10 million gallon per year (gpy) capacity plant. The inputs include site characteristics, utilities, production capital, and permits. The additional waste grease section includes equipment needed to collect waste grease and make it suitable for biodiesel production.

(Duff, 2004) proposes the exact parameters for each input in their feasibility study. For instance, a 10 million gpy plant in their study uses 7500 BTU/gal biodiesel and ~0.07 to 0.1 kWh/gal biodiesel for electricity[19]. Marketing expenses, installation of sprinklers, additional construction to comply with needs and permits, loan rates, blending permits and blending process are also important planning considerations (Duff, 2004).

Table 5.1

		Plant Framework		
Site Characteristics	**Utilities**	**Production**	**General Permits**	**Waste Grease**
10 to 20 acres rural industrial	steam	processing unit	Air Quality Permits	insurance
Access to low cost feedstock	water	methanol/ethanol	Storage Tank Permits	registration
rail access	electricity	Catalyst	Water Quality Permits	fuel
				rendering
road access	waste water	Feedstock	State Department of Motor Fuels	license
Close proximity to co-product	Cooling	maintenance		
markets	water	material	State Department of Transportation	drivers
Labor			Highway Access Permit	
			Possible Easement rights	
			State Department of Health	
			State Department of Public Service	
			Boiler License	
			State Department of Natural	
			Resources	
			Water appropriation permits	
			Other waters and wetland	
			considerations	

Source: (Duff , 2004)

Table 5.1 displays the general inputs of a 1million gallon per year (gpy) capacity plant. The inputs include site characteristics, utilities, production capital, and permits. The additional waste grease section includes equipment needed to collect waste grease and make it suiTable for biodiesel production.

5.3 Oakland Plant Construction

Plants are constructed several ways. For instance, many companies offer to build complete plants, while many biodiesel production facilities have on site qualified engineers to build their plant. The major difference in each option is the cost of construction. A 10 million gpy plant, built by a manufacturing company, is approximately $0.95 per gallon of capacity. Accordingly, a 10 million gpy will cost about $10 million. On the other hand, a plant with capacity under 10 million gpy, ranges between $1.30 and $1.50 per gallon (Wright, 2006). Another method was also uncovered when calling a California waste grease based biodiesel company called Imperial Western, located in Indio. Imperial Western will sell there plant model. During an interview a representative quoted $100,000 for plans of a plant that produces approximately 4 million gallons from waste grease (Wright, 2006). The representative was unable to disclose additional costs of materials, but suggested total costs would be significantly less than having a plant manufacturer construct the entire plant. This brings up another point. When building a plant it is imperative to decide what feedstock(s) will be used beforehand, because the plant is typically constructed based on that feedstock processing unit[20]. Seemingly the most cost-effective method of construction is to have a qualified staff engineer design and construct the plant. For instance, Seattle Biodiesel proved their concept with a 5 million gpy plant and around a quarter million dollars in investment, and a staff of extremely experienced personnel (Tong, 2006). Notwithstanding this evidence, there are obvious concerns when having an engineer build a plant. Of course, it is imperative to verify experience. Poor planning and unforeseen costs often run biodiesel start-ups in the ground. When there is no previous experience building a plant, costs of equipment, construction, and time to complete the project can be mistakenly estimated. Furthermore, choosing an inadequate site is equally problematic.

The feasibility of a plant is location specific. The proposed plant model in (Duff, 2004) assumes construction will take place in the Midwest. Midwest plants are subject to very different cost restraints than a plant in Oakland. For instance electrical costs may be higher on the West Coast. Other inputs may vary in price as well. "Virgin" soy oil costs will be inevitably higher. Table 5.2, from (Duff, 2004), depicts the various inputs, outputs, and transportation associated with a plant that produces 3 million gallon per year (MMGY), 5 MMGY, and 10 MMGY.

Table 5.2

Oil Extraction and Biodiesel Production Plant Statistics			
Production Inputs	**3 MMGY**	**5 MMGY**	**10 MMGY**
Oilseeds (tons/yr)	37,500	63,000	126,000
Oilseeds (bu/yr)	1,250,000	2,100,000	4,200,000
Water (gal/yr)	3,720,000	6,200,000	12,400,000
Electricity (kWh/yr)	4,500,000	7,500,000	15,000,000
Natural Gas (MCF/yr)	28,050	46,750	93,500
Chemicals & catalysts (tons/yr)	1,656	2,782	5,564
Production Outputs	**3 MMGY**	**5 MMGY**	**10 MMGY**
Oilseed meal yield (tons/yr)	26,250	43,750	87,500
FAME (Biodiesel) (gal/yr)	3,000,000	5,000,000	10,000,000
Soapstock (tons/yr)	1,937	3,228	6,456
Wastewater (gal/yr)	1,636,800	2,728,000	5,456,000
Incoming Transportation	**3 MMGY**	**5 MMGY**	**10 MMGY**
Oilseed (Trucks/yr)	938	1575	3150
Chemicals & catalysts (Trucks/yr)	42	70	70
Total Trucks Inbound per Day	3	5	9
Total Trucks Inbound per Year	980	1645	3220
Outgoing Transportation	**3 MMGY**	**5 MMGY**	**10 MMGY**
Degummed Oil (trucks/yr)	600	1000	2000
Oilseed Meal (trucks/yr)	656	1094	2188
Gums (trucks/yr)	97	161	323
Total Trucks Outbound per Day	4	6	13
Total Trucks Outbound per Year	1353	2255	4510
Outgoing Transportation	**3 MMGY**	**5 MMGY**	**10 MMGY**
Total Trucks per Day	7	11	22
Total Trucks per Year	2333	3900	7730

Source: (Duff , 2004)

Table 5.2 depicts the various inputs, outputs, and transportation associated with a plant that produces 3 million gallon per year MMGY, 5 MMGY, and 10 MMGY. The units are located in parentheses next to each parameter.

During the progress of this study a proprietary financial model was created. It models the fiscal feasibility of a biodiesel facility in Oakland that will produce up to 5 million gallons per year. The model ran scenarios based on blends ranging from B5, B20, and B100. The model also ran feedstock scenarios ranging from waste oil only, to a combination of waste and virgin feedstock. Depending on up-front capital investment, and how the plant is built the model suggests the plant breaks even in year two[21]. Barriers to establishing a site create tumultuous characteristics in this model.

5.4 Barriers for Biodiesel Production in West Oakland

The main goal of any biodiesel producer is to produce in the immediate area of a centralized market. This reduces expensive transportation costs. West Oakland is the closet area to the Port of Oakland, the centralized users of diesel, and a target market for biodiesel. However, many attempts to cite a biodiesel production facility in West Oakland have been time consuming and result unsuccessfully. Several uncertainties based around the real estate market in West Oakland are perpetuating the challenges facing biodiesel production. For instance, the current trend is that residential areas are replacing industrial areas. Industrial areas are being ‘re-zoned’. These transformations are being driven by a number of disputes. First, the residents of West Oakland are pushing for the removal of “dirty” industry that has plagued their community for years. Furthermore, real estate investors want high return on real estate and impose political pressures to achieve these returns. Moreover, industry is being driven out by the notion that commuters to San Francisco are making West Oakland the busiest Bay Area Rapid Transit (BART) station in the Bay Area, as they find it timelier to commute from West Oakland to downtown San Francisco, than from many parts of San Francisco itself.

Lastly, there is the issue that West Oakland is simply expensive and uncertainties will significantly persist across the board; at least until it is clear that is going to impose political pressure in the near future (Lautze, 2006).

The last few sections have laid out inputs, options, and impediments for production of biodiesel in West Oakland. The discussion noted that feedstock is the most sensitive input. It can truly affect the variable costs of production. In addition to the sensitivity of feedstock, certain exogenous variables like the federal excise tax are essential to the costs of production. As important to each of these, is having sustainable production as a major goal. Furthermore, zoning and permitting are big factors on moving a facility into West Oakland. Finally, successful business practices are just as essential. One of the final, critical elements is having a good business model. (Duff, 2004) makes the amount of planning that needs to go into a facility very explicit. A follow up meeting with Nth Power Venture Capital Firm, helped to compile a short list of significant considerations when starting a biofuel business:

1) Technical and Managerial Expertise
2) Proprietary Technology
3) Initial Investment (Sufficient funding to prove concept before VC funding)
4) Management Team and Planning
5) Decisions on Feedstock
6) Competitive Barriers
7) Investment Strategies[22]

Part of good planning is also knowing the sensitivity of certain input parameters to change in price and availability, as well as anticipating uncertainties that can evolve into problems facing the business (Tong, 2006).

5.5 Volatility in the Waste Grease and Soy Oil Market

Feedstock is a very unstable input. Inherently, the variability around any feedstock is derived by two primary factors, supply and price. Take the supply of waste grease and soy oil as an example. Waste grease and soy oil are both renewable. However, the finitude of each feedstock is based on annual production capacity. There is only so much land for soybean crops, and restaurants only generate a certain amount of waste grease per year. Annual capacity is further reduced by regional access. For instance, the U.S. annual production of soy oil and waste grease is a fraction of world production. But because it is uneconomical to internationally import soy oil, the availability of feedstock is limited to the soy oil in the U.S. region. Price is also unstable. Although the supply of waste grease is fairly certain in the Bay Area, the ability to acquire waste grease at a steady price is volatile. Remember, price volatility in waste grease was explained in the section on commoditization. In a way, soy oil and waste grease prices are related to the amount of that feedstock allocated for biodiesel. For instance, the EIA forecasts soy oil prices to be directly related to soy-based biodiesel demand. Essentially, the more soy oil used for biodiesel, the higher the price of soy oil. This notion is the use-specific price elasticity of soy oil.

5.6 Soy Oil Supply Forecasts and Use-Specific Price Elasticity

Soy oil is plentiful, at least in the near future (www.eia.doe.gov, 2006). The EIA states, there are at least 200 million gallons of soy oil available for biodiesel production, and other, more efficient feedstocks are being developed daily(www.nbb.org, 2006). Currently, the price, not the demand of feedstocks, is subject to the highest volatility. The term use-specific price elasticity refers to the amount the price fluctuates based on the amount of that feedstock used for biodiesel. There is a direct relationship between price of soy oil and the amount of soy oil that is used for biodiesel. Fig. 5.5 displays EIA soy oil forecasts as two functions that depict price through time based on soy oil allocation to biodiesel end-use (www.eia.doe.gov, 2006). The high line represents the costs of soy oil if 200 million gallons are used for biodiesel. The bottom line represents the price of soy oil if only 50 million gallons are used for biodiesel. The NNB claims actual production was 75 million in 2005. So, the two dashed lines in Fig. 5.5 begin at the 2005 suggested production level and offer two potential trends in growth, or two prospective views of price increase as biodiesel production grows.

Fig. 5.5

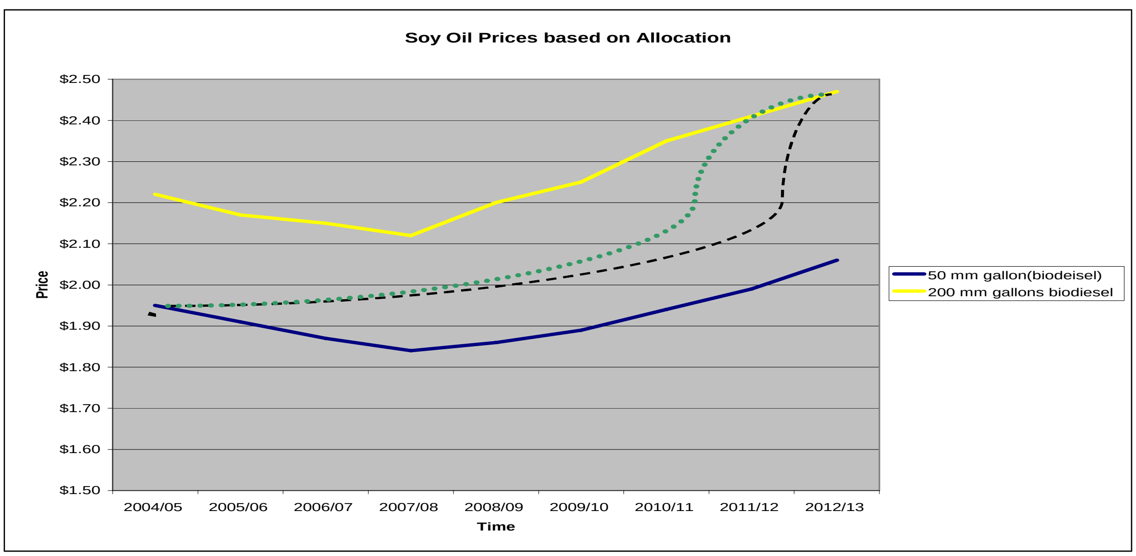


***Fig. 5.5 displays EIA soy oil forecasts as two functions that depict price through time based on soy oil allocation to biodiesel end-use. The high line represents the costs of soy oil if 200 million gallons are used for biodiesel. The bottom line represents the price of soy oil if only 50 million gallons are used for biodiesel. The two dashed lines in Fig. 5.5 display two alternate trends for allocation.** Source: (www.EIA.doe.gov, 2006)*

5.7 Exogenous Variable Assessment

Exogenous variables also affect the costs of biodiesel production. Exogenous variables are forces external to the economic market. Take the Elmo Sesame Street Doll for example. It sold millions and millions in the late 1990's. Every child that didn't have one wanted one. But the Elmo doll did not sell so well because of economic market characteristics like supply, demand, or price. At first rapid sales sparked interest in the media. The media began giving it massive publicity, it just blew up. Then it sold incredibly well because of all the media around it. In this case, media exposure is an exogenous variable. Likewise, the recent "publicity" that alternative energies received from President Bush has spiked the investment in alternative fuels (Tong, 2006). Although economic market characteristics like low prices can dramatically increase the use of biodiesel, this is not the reason for the recent surge in venture capitalists investment. The supply, demand, and price have not really changed since President Bush gave his speech, yet investment has drastically increased as a result of the media exposure of biodiesel. Like media exposure, regulation is an exogenous variable, something not directly linked to the typical economic market that can significantly affect the way the product sells (or does not sell)[23].

Fig. 5.6

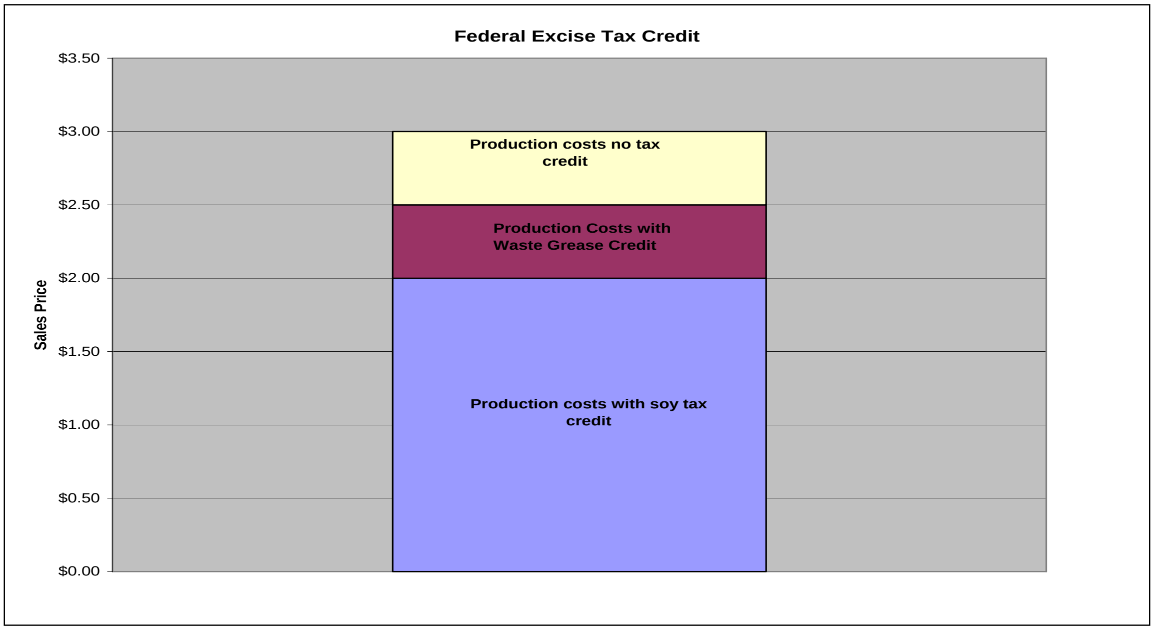


Fig. 5.6 assumes production costs are $3.00 for a gallon of biodiesel. Under this assumption the $1 soy tax credit knocks down production costs to about $2.00 per gallon. Waste grease tax credit is $0.50.

The federal excise tax credit is an example of a critical exogenous variable for biodiesel. It provides approximately one dollar per gallon for soy based biodiesel production, and fifty-cents per gallon for waste oil biodiesel production[24]. The federal excise tax credit has been extended through 2008, but biodiesel may not be cost competitive without it. This issue requires looking directly at the marginal production costs of biodiesel. The following scenarios use the forecasts of the EIA, and the proprietary model developed in this study to look at the costs of production with and without the federal excise tax credit. Fig. 5.6 assumes production costs are $3.00 for a gallon of biodiesel, a fairly high estimate[25]. Under this assumption the soy tax credit knocks down production costs to about $2.00 per gallon. The point is if the tax credit were abolished biodiesel retailers would have to sell fuel for $3.00 per gallon to break even[26]. This means diesel would have to raise over $0.40 per gallon from April 2006 on-highway EIA prices, for biodiesel even to be marginally cost competitive. Consider a different, more realistic approach. Fig. 5.5 shows soy oil prices to be around $2.40 per gallon if 200 million gallons were allocated to biodiesel. This means that marginal production costs of biodiesel minus the costs of feedstock would have to be no more than about $0.38 per gallon for biodiesel to break even competing with April 2006 diesel prices of $2.78 per gallon. This is a very small operating margin. Other efforts, such as the West Coast and the WOTRC, are prime examples of exogenous variables that will perpetuate the adoption of biodiesel.

Sustainable Feedstock Options

Sustainability is a word that is being used more and more in the environmental field. However, there are many definitions of sustainability. A sustainable feedstock can be defined as one that sustains energy supply to meet specific demand by minimizing environmental and social externalities associated with production and distribution. The sustainability of biodiesel can be discussed on global, national, regional, and individual production levels. A Lifecycle Analysis (LCA) of biodiesel starts in the fields where the crops are grown and ends at the tailpipe of the end-user. Therefore it is understandable that more land area encompassed in the scale of the LCA the more difficult for the life cycle of biodiesel to be sustainable.

Let's take a specific example. Waste oil based biodiesel presents a fairly sustainable life cycle, from start to finish. First, the waste oil feedstock is collected locally therefore there are few externalities associated with transporting it to the facility. Soy oil, on the other hand comes from the Midwest either by rail or large trucks. Using waste grease also diverts a waste stream. Once it is transported safely within the local area, the waste grease is then converted in a local production facility into fuel that is then burned for cleaner air in the same community. However, this cycle can create externalities in the community. For instance, collecting the waste grease in highly polluting vehicles and distributing the fuel in similar vehicles reduce net emissions reductions, compromising the sustainable nature of the process. Obvious consideration such as electricity and waste further add to the list of environmental concerns.

Waste grease is limited. The cycle just explained is fractured when feedstock must be imported. When feedstocks are imported the environmental considerations must be expounded. Imagine a theoretical sphere drawn from the Midwest to California. Within this sphere, conceptually trapped are all the social and environmental externalities, or of biodiesel production at one plant. It encompasses the fuel that is being burned in the rail cars and the fuel in the trucks that import the feedstock, the agricultural praxis utilized to grow that feedstock; large scale farming equipment can generate massive emissions. In addition, the sphere expands with consideration of run–off from the pesticides and fertilizers used to grow the crops. These are all issues to discuss with the feedstock producers and transporters. A positive side to this discussion is many soybean farmers use their own crops for fuels, and may have sustainable agricultural practices. It is critical to the sustainable nature of biodiesel that producers of fuel on the west coast choose these producers as a more sustainable alternative.

Soy oil is it is finite, or limited to annual production capacities which are based on available arable land as well as cost effective alternatives to use soybean crops for subsistence needs. Soybean products are widely consumed, creating the issue of supplanting edible crops for fuel. There are other biodiesel feedstocks that are not edible.

Jatropha oil is one. It is a non-edible crop grown on a large scale in East Asia. For example, Jatropha is being harvested on a large scale in India. Jatropha has many significant characteristics that make it a feasible feedstock. It can grow almost anywhere, Biodiesel Technologies© are in the final stages of research to grow it on the side of highways. According to Biodiesel Technologies, it is also 3 times more efficient than soy oil; it yields 175 gallons per acre compared to 50 gallons per acre that soy oil yields. Palm oil is another feedstock which is being harvested in Asia. Moreover, algae and seaweed are still in R&D phases, but demonstrate great promise as sustainable feedstocks. An important issue is that some feedstocks can produce more fuel per acre than others. The following is a break down of this efficiency measure of alternate feedstocks.

Soybean: 40 to 50 US gal/acre (40 to 50 m^3/km^2)
Rapeseed: 110 to 145 US gal/acre (100 to 140 m^3/km^2)
Mustard: 140 US gal/acre (130 m^3/km^2)
Jatropha: 175 US gal/acre (160 m^3/km^2)
Palm oil: 650 US gal/acre (610 m^3/km^2) [2]
Algae: 10,000 to 20,000 US gal/acre (10,000 to 20,000 m^3/km^2)

Source: Biodiesel Technologies

6. Limitations and Explanations: Costs, Engine Problems, and NOx

Biodiesel has proven to be a realistic and pragmatic replacement in diesel engines around the world including grand success in Europe and the Midwest. Farmers, fleets, and other end-users in the U.S. use B100, B20, and B5 effectively. Minnesota has a statewide mandate for low-level blends of biodiesel to be put in every single gallon of diesel sold in the state (www.nbb.org, 2006). The State of Washington, with the support of Seattle Biofuels, aims to have B2 blend mandated in every gallon and ramp up to B5 as soon as possible (www.seattlebiodiesel.com, 2006). Despite overall success three major limitations persist. Biodiesel often costs more than diesel, engine problems can occur with biodiesel, and biodiesel may increase Oxides of Nitrous (NOx). A study conducted by the City of Oakland did not have any reported engine problems, but found converting to B20 was expensive, and resulted in increased opacity[27] in some engine types. If proper transportation and maintenance techniques are not practiced fuel can become contaminated, and studies show NOx emissions increase with biodiesel above that of certification diesel. Each of these limitations can be mitigated; this section focuses is on engine problems and NOx mitigation. Cost competitiveness is discussed thoroughly during recommendations.

6.1 Past local experiences: The Cities of Berkeley and Oakland

The City of Oakland and the City of Berkeley tested biodiesel and each test, for disparate reasons, resulted in admonishing the use of biodiesel. In the Oakland study, ten city-owned vehicles were tested for six-months using B20 biodiesel from an unreported source. The total range in age of vehicles was 1994 to 2003 models. Oakland rented a

1,000-gallon stand-alone tank from a non-referenced source. The Oakland study consisted of monitoring opacity, or smoke output. The methodology of measurement is undisclosed in the report. The results varied and older vehicles showed opacity decreases with biodiesel. The Oakland report does not mention any mechanical issues during the test phase; however, the major limitation of biodiesel for Oakland was the cost. Biodiesel was $0.54 more per gallon for B20 (Edgereley, 2005). Assessment of specific emissions was not conducted.

Edgereley, 2005 does mention the City of Berkeley having mechanical problems from the use of biodiesel. The possible problems included corrosion, filter clogging, injections coking, and contamination (Edegerley, 2005). However, a memorandum issued in March 2006 from the City Manager to the Honorable Mayor, noted the intent of Berkeley to recommence use of B20 by June 2006 (Kamlarz, 2006). The City of Oakland does not mention any of these problems during their six month study. Speculations as to the root of the mechanical problems in Berkeley range from fuel quality to maintenance reduction after a key biodiesel advocate and program affiliate left the City of Berkeley.

Each of these examples demonstrates the types of specific issues associated with biodiesel use. Essentially, the quandary in Berkeley was one of microbial contamination in the tanks of the city, while in Oakland cost was the main impediment. Microbial contamination occurs when water comes into specific contact with the fuel, or under certain situations of oxidization[28]. The following section expounds on microbial growth.

6.2 Explanation of Microbial Contamination

Water and oxidization are two major sources of fuel contamination. Fuel and water generally come in contact while in the distribution and storage network. Water can enter the fuel tank through areas such as vents and seals. Water in the fuel generally causes two problems. First, it can cause corrosion of engine fuel system components, typically rust or occasionally acidic corrosion. The case experienced by the City of Berkeley possibly exemplifies water contamination that contributed to microbial growth (Van Gerpen et al 1996). According to Van Gerpen et al 1996 there are species of yeast, tingi, and bacteria that will grow at the interface between the fuel and any free water that has collected at the bottom of a storage tank. The result is filter plugging[29]. In addition to water, oxidation of biodiesel was identified in the same study as a major source of biodiesel contamination. This type of contamination leads to alteration of the chemical bonds, influencing the fuel to attack elastomers. The result is the enhancement of sedimentation and formation of gumming deposits.

6.3 Prevention of Microbial Growth

Microbial growth is preventable. The amount of water dissolved in the fuel depends on the fuel's solubility (Van Gerpen et al 1996). This is important because biodiesel is fairly soluble, and therefore subject to higher levels of water being dissolved. For instance, methyl soyate (soy based biodiesel) can contain up to 40 times more dissolved water than diesel fuel. In fact, if methyl soyate comes into contact with free water during transport and storage, which is a near certainty, it will absorb 1200-1500 ppm of this water[30]. The higher the level of maintenance practiced the less water. The following are methods for preventing contamination:

1) Frequently draining the water from storage tanks and ensuring that vents and seals do not allow rainwater to enter.

2) To prevent large amounts of free water from contaminating the system do not draw from the bottom of the tank.
3) In applications where the fuel is expected to come into contact with sufficient quantities of free water to support the growth of microorganisms, the fuel should be treated with a biocide to prevent their growth.
4) Taking the proper steps to ensure rapid sales of fuel and storage avoiding severe amounts of heat and light are simple precautions to prevent oxidization.
5) Use a biocide if fuel is stored for long periods of time[31] (Van Gerpen et al 1996).

6.4 Demystifying Concerns about NOx

Biodiesel has been found to increase NOx in several studies. The following sections use data from two National Renewable Energy Laboratory (NREL) reports on biodiesel emissions and NOx solutions for biodiesel to summarize additives that are shown to reduce NOx during the combustion process of biodiesel[32].

Earlier in this report, it was mentioned that chemical structure affects fuel properties, which in turn affect emissions. In that section, the relationship between chemical structure and emissions was described. This section endeavors into a more in-depth look at fuel properties and their specific impact on NOx. Two extremely relevant reports are reviewed here to explain the reasons NOx emissions occur and how to reduce these emissions[33]. By analyzing different feedstock emission characteristics and the chemical properties of those feedstocks a relationship between fuel properties and emissions can be derived. During a series of tests in these reports, soy based biodiesel resulted in NOx increase in almost all cases[34].

6.5 NOx related to Iodine Number, Olefinic Bonds, and Chain Length

Molecular structure determines fuel properties such as density and cetane number. Cetane number and density are fuel properties that have a direct relationship with NOx emissions. More saturated esters, that is esters with more olefinic, (carbon-carbon double bonds) have higher cetane numbers and lower densities than less saturated esters. According to U.S. Code, cetane number refers to the ignition quality of the diesel fuel oil. The higher the cetane number the less ignition delay, resulting in higher quality combustion, meaning the user gets more “bang for the buck.” Iodine number, another fuel property, is measured by “titrating” the olefinic bonds in the fuel. Titrating establishes the weight of the iodine required to fully saturate the molecule. This is important because iodine number and cetane number are related to the number of double bonds in a molecule. Cetane number and iodine number are also inversely related, and a higher cetane numbers result in substantial NOx reduction. Thus the lower the iodine number, the lower the NOx emissions[35] (Graboski et al 2003). Tests in NREL report 2 affirm the inverse relationship between cetane number and NOx. In numerous tests, cetane-enhancing additives reduced NOx emissions[36] (McCormick et al 2003).

6.6 NOx Solutions

NREL Report 6, entitled NOx Solutions for Biodiesel, tested these specific solutions to NOx reduction. The test methods were rigorous[37]. The following B20 fuels were prepared and tested both with and without the di-tert-butyl peroxide additive

(DTBP)[38], a cetane-enhancer. Ethyl-hexyl nitrate (EHN) was also tested as a cetane and enhancer and also reduced NOx.

- Certification diesel + yellow grease
- 10% aromatic diesel + soy
- 10% aromatic diesel + yellow grease

The engine used in NREL report 6 is a 1991 calibration series 60 production model loaned to CSM by the Detroit Diesel Corporation[39].

Solutions for NOx reduction in B100 and B20 blends[40]:

NOx Neutral	**NOx Reducing**
• Blending FT diesel at very high percentages	• Lowering the base fuel aromatic content from 31.9% to 7.5% (i.e. nominally 10% aromatic fuel)
• Using a base fuel, or kerosene base fuel having 25.8% aromatics should provide a NOx neutral B20	• The cetane enhancers di-tert-butyl peroxide (DTBP) and ethyl-hexyl nitrate (EHN)

Source: (McCormick et al 2003)

The following are specific findings from NREL report 6:

6.7 General NOx Reduction

- DTBP at 1.0 volume percent will add on the order of $0.16 per gallon and EHN at .05 volume percent will add on the order of $0.05 per gallon to the cost of biodiesel.

- Blending with a low aromatic diesel, kerosene, or Fisher-Tropsh diesel is also effective at reducing NO_x.
- The antioxidant TBHQ significantly reduced NO_x but also caused a small increase in PM[41].
- Short chain fatty acid esters were not effective for NO_x reduction.
- Lowering aromatic content to roughly 25% and addition of cetane improver would be necessary for NO_x neutrality relative to 10% aromatic fuel[42].

6.8 DTBP in B100

For DTBP testing in NREL report 6, a 5% DTBP blending level was used for testing B100.

- Soy B100 increases NOx to 5.45 g/bhp-h yet, adding DTBP results in a decrease to 5.18 g/bhp-h 36 For yellow grease B100 (Bio3000) NOx is 5.07 g/bhp-h and adding 5% DTBP reduces NOx to 4.88 g/bhp-h. This NOx reduction is statistically significant, and reduced NOx to the certification fuel level.
- DTBP is also effective at NO_x reduction for B100 fuels but not in proportion to the NO_x reduction observed for B20 blends.

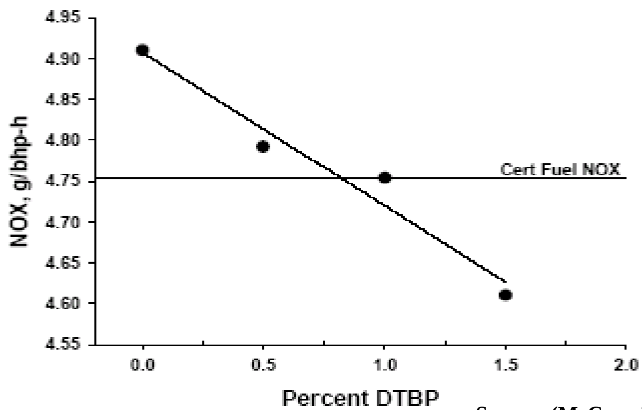
6.9 DTBP in B20

- DTBP was effective at reducing NO_x emissions to the base fuel level or below (by 3% to 4%) in all cases for B20[43].
- The cetane-improvers DTBP and EHN are effective for reducing NO_x by 4% in B20 blends.
- The NOx emissions of biodiesel with DTBP added drop below certification fuel NOx emissions when approximately 1% DTBP is added to B20.

6.10 California Air Resources Board (CARB) Certification for Biodiesel

NREL report 6 also discusses the fuel additive options that are most likely to gain CARB certification. According to California Code of Regulations Title 13 Section 2282

Fig. 6.1 DTBP in B20

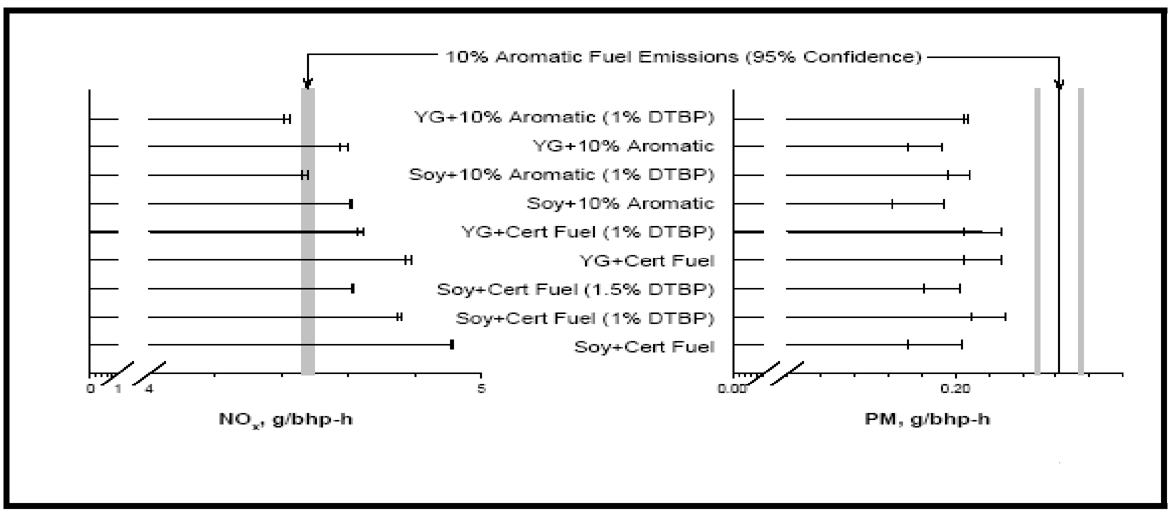


Source: (McCormick et al 2003)

Fig. 6.1 compares percent added of DTBP to NOx emissions in B20 fuel.

For a biodiesel fuel to be considered CARB certified, it must be proven to have emissions equivalent to a 10% aromatic CARB reference diesel or have less than 10% aromatic content. B20 blends produced from the 10% aromatic fuel and including DTBP were NOx equivalent or better. Thus blending of biodiesel with a California compliant diesel and treating it with DTBP may be a route to a CARB certifiable B20. PM and NOx emissions are shown respectively in Fig. 6.2. The vertical axis displays B20 blends of biodiesel. The list of blends includes waste grease and soy blended with certification diesel and 10% aromatic diesel, and each B20 blend with DTBP added at 1% and 1.5%. In Fig. 6.2, the grey bars show 10% aromatic fuel emissions. All PM emissions for each blend and blend with DTBP are less than 10% aromatic constant. However, NOx emissions are only significantly less with Yellow Grease (YG) + 10% aromatic (1% DTBP) and slightly less when DTBP is added to soy + 10% Aromatic. Also, the fact that each blend with DTBP produces less NOx emissions and similar PM emissions compared to soy + cert diesel without DTBP is very noteworthy when considering options to reduce NOx emissions below certification fuel level.

Fig. 6.2 Comparison of B20 Emissions for 10% aromatic diesel



Source: NOx Solutions for Biodiesel

Fig. 6.2 compares biodiesel blends with 10% aromatic fuel emissions. The gray bar signifies the baseline 10% aromatic for NOx (left) and PM (right).

Costs of certification testing and CARB test specifications is a prohibitive barrier to CARB compliant fuel development, and working through these will expedite the certification process.

6.11 Retrofit Options to Control NOx Emissions for Biodiesel

Beyond fuel additives and altering fuel chemistry, post- combustion retrofit devices can be placed on most diesel-using equipment to reduce PM and NOx emissions. These emissions controls are currently on market and in use and warrant in depth discussion for use with biodiesel and biodiesel blends. For instance, there is significant potential to gain CARB certification for biodiesel with these controls. But the costs of installation and operation are important limitations because every piece of equipment is different, resulting in the need for specific mechanical expertise depending on the type and age of equipment that will use the retrofit device.

7.) Recommendations for Stakeholders and Key Players

Vegetable oil is an age-old fuel that Otto Diesel himself knew worked in the diesel engines he designed. Not only has biodiesel been proven to work in engines, biodiesel also reduces toxic emissions. Biodiesel is alluring because it requires little to no engine modification, and it results in pollution abatement the very same day it is used. Biodiesel is growing at rapid rates. As a nation we've seen it go from just 500,000 gallon in 1999 to 75 million gallons in 2005. As mentioned, U.S. biodiesel production is expected to grow to 475 million gallons by 2010 as a result of renewable portfolio standards and ULSD rules[44]. So the question remains, what does this all mean for West Oakland, the WOTRC, and others who are working hard to clean up the air the residents in the community breathe? This question is addressed through detailed recommendations. The following section is a chronological guide to implement biodiesel use. As time progresses, obviously, the order may change, and some steps may be added to the process. Some of the recommendations may be fused or integrated, and some may even become obsolete. This section should be used a basic guide to begin the steps of near and long term biodiesel implementation. The WOTRC is group of major stakeholders from diverse sectors, with the ability to set timeline-based, stringent goals for emissions reductions. However, it should be a step-by-step plan. Indeed setting goals are important, however, stakeholders must have a realistic expectation in terms of what biodiesel will achieve as one of several approaches to cleaner air in WO.

Phase 1: Discussion and Education

1. Discuss Biodiesel with the Community

2. Survey End-Users

3. Educate End Users

Phase 2: Use and Production

4. Cost Competitiveness

5. Streamline Zoning and Permitting

6. Implement the Use of Biodiesel

7. Recommendations for Biodiesel Producers

8. Prevent Fuel Contamination

9. Ensure the Safety of Community

Phase 3: Ongoing Steps to Support the Success of Biodiesel Implementation

10. Stakeholders Must Stay Involved in Discussions Around the Federal Excise Tax Credit.

11. Conduct Dialogue with East Bay Municipal Utility District

12. Establish Ways to Reduce NOx and Gain CARB Certification

Phase 1: Discussion and Education

1. Discuss biodiesel with the community

A long-term problem in West Oakland has been industrial pollution. Now industry is sparse in West Oakland. This poses an issue for an industrial scale biodiesel business. However, biodiesel production is hardly representative of major industries that have plagued West Oakland, such as Red Star Yeast, who was responsible for thousands of pounds of carcinogenic emissions in West Oakland every year. Comparably, biodiesel production is actually an innocuous process. For example, 100% biodiesel has a 300 degree flash point, or the temperature at which the fuel combusts. A flash point of 300 degrees is over twice that of conventional diesel, minimizing the danger of storing it onsite. The example of Seattle Biodiesel is ubiquitous throughout this report because it provides a model for port based biodiesel use. Seattle Biodiesel stationed their 5 million gallon per year plant in downtown Seattle, demonstrating that biodiesel production is compatible with other land uses. That being said, there are some concerns about bringing biodiesel into the community. Although the finished biodiesel product has a high flash point, biodiesel production requires bringing some volatile chemicals into the community. For instance, methanol and acidic catalysts like lye are both used in biodiesel production and constitute two large risks at a production facility. This is the same risk the Seattle Biodiesel poses in downtown Seattle.

Discussing biodiesel with the community should be a priority of the WOTRC. There are two major steps in this discussion with the community. First, potential biodiesel production sites must be determined. This requires a tour of West Oakland with a few key members of the WOTRC to determine feasible sites. A representative from the City of Oakland[45], biodiesel producers, as well as at least one member of the WOEIP will be key participants when setting a list of sites. It is essential to have all these people involved because the city representative knows what sites might be most feasible, while producers know what land is suiTable for their plant capacity. For instance, some producers may have plans for a 5 million gallon plant and others may have plans for a 20 million gallon plant. Therefore each producer's specific needs will vary. Of course, it is also inherent to have the community representatives to help determine what locations will suit the residents of West Oakland. A list of five to ten sites is a good goal. This will give some leeway if a few sites do not prove suiTable with further analysis or if land owners are not willing to lease to biodiesel producers. Once sites are determined, the next step is to determine the most respecTable means to truly discuss biodiesel production at the selected sites. The WOEIP may have specific objectives in the site selection discussions with community. One suggestion is disseminate information to the residents of West Oakland regarding the nature of biodiesel production including where the potential production sites are located. The information disseminated should also solicit concerns from the community, and their concerns ought to be addressed at community meetings. The NBB website has ample information regarding the nature of biodiesel production. Student Science Advisors For the Environment (SSAFE) students from USF in collaboration with WOEIP may be willing to undertake this task as part of their spring semester in 2007.

2. Survey End-Users

There is still another group of stakeholders to discuss and educate in the process of implementing biodiesel. These are the end-users. In many cases, it is hard to determine what drives their decision making. To make the educational process efficient, a survey of end–users should precede information dispersal and discussions.

Implementing alternative energy often requires consumers, or end-users, to choose to use that energy. Case in point, take the current way "green" or clean electricity is purchased in California. Wind power is a good example. It is produced largely in Alta Mont pass. In turn, the power is connected to the electrical grid to be sold. Safeway® is an example of a large-scale energy user who purchases clean electricity (www.safeway/windenergy.com, 2006). This requires a conscious effort by Safeway® to use clean energy, as opposed to typically generated electricity[46]. Now, the great thing about this method to distribute green electricity is that it does not require the end-user to do anything but purchase the energy and track it through Renewable Energy Certificates (www.safeway/windenergy.com, 2006). More importantly, the consumer does not have to go out and purchase infrastructure. For instance, when using solar panels, the end-user has to buy solar panels, pay to have them installed, and then purchase a new meter. This is a big decision for the consumer, and often results in an outlay significant up front cash.

Using biodiesel is similar to the way Safeway® uses "green" electricity. Unlike solar panels, biodiesel does not require the diesel end-user to purchase any new device to use the fuel. However, like getting electricity from a clean source, it requires the conscious effort of the consumer. Diesel-users in West Oakland are not as interested in their environmentally responsible reputation as a large chain like Safeway®. Therefore the diesel consumer must be educated on the environmental and mechanical benefits of biodiesel to propel their conversion[47]. Of course we cannot under appreciate economic incentive.

The end-users of diesel include, but are not limited to, truckers and trucking fleets, terminal operators at the Port of Oakland, and the US Postal Service Distribution Centers in West Oakland. By surveying end-users of diesel first, the WOTRC will know what concerns they have, and thereby what content to include when presenting information.

In the near term this will require a brief survey be compiled and disseminated to end-users. The survey should probe environmental issues, end-users concerns, and other pertinent questions. Once the survey is complete it may require port personnel to submit it to terminal operators, whereas other WOTRC members are more affiliated with truckers and can choose an efficient location such as trucking scales to conduct the survey[48]. This is also a perfect task for SSAFE from USF. The main objective in the survey is to obtain as many critical answers as possible. Therefore it should be brief, and even better, never leave the hands of those who are surveying. It could even be administered over the phone to terminal operating staff, ideally those who handle purchasing the fuel for their operation[49].

3. Educate End Users

As of 2006, Ultra Low Sulfur Diesel (ULSD) is required in California. Sulfur increases the lubricity in diesel. Engines require that fuel have lubricity to reduce friction that rapidly debilitates engine parts. Sulfur is removed from diesel to make ULSD, and the lubricity is lost. Biodiesel blends, as low as 2% biodiesel 98% diesel, provide desirable lubricity in diesel fuel. The problem is that most diesel users are not aware of this connection between ULSD diesel and biodiesel. In addition to a general response to the surveys, information should explain the mechanical impact of ULSD (ideally in different year engines) and how in turn biodiesel use can increase the life of the engines. There is a sizeable amount of information about biodiesel that needs to be disseminated to diesel end-users, but providing information in small strategic quantities will make the messages more effective.

There are many ways to conduct this educational process. Linda Hothem, the owner of the Free Trade Zone in Oakland, suggested that a grass roots movement is necessary to change the fuel consumption patterns of truckers to biodiesel by targeting them while in line at the port. Another way to educate truckers is in the plans of Dr. Fine's proposal from the University of San Francisco. He aims to educate truck drivers about biodiesel using a grass roots movement by targeting them at scales. Furthermore, informing truck drivers about biodiesel will establish fundamental understanding that paves the way for producers to enter the market. In the near term information dissemination from the community and through publicly funded projects is a great way to boost the biodiesel demand in West Oakland. EIP can also work with USF to find a marketing major or Master's of Business Administration (MBA) student to compose the information so that it is catchy and sticks with the drivers. Once the information is available formatting can be completed in approximately a week. However, in the long run informing the end-users and influencing the use of biodiesel is the role of the producer[49].

Phase 2: Use and Production

4. Cost Competitiveness

Over the long term, biodiesel will need to be cost competitive with diesel to encourage end-use. Biodiesel can achieve cost competitiveness either by reducing the costs to produce (like the federal excise tax credit, using waste grease, plus reaching economies of scale) or reduce the price the end-user pays (price subsidy). Assume in the next year that production has not come online in West Oakland, but some end-users have agreed to begin testing biodiesel if it does not cost them more than diesel. This will require the fuel to be transported from a producer outside of West Oakland. If the fuel costs more than conventional diesel the price will need to be subsidized, since the end users require the fuel to be evenly priced with the diesel they consume. On the other hand, if production is under way in West Oakland the costs of producing the fuel and supplying the market are already lower because of the proximity of production to distribution of the fuel because producing in the in the vicinity of the centralized port market dramatically reduces transportation costs. Despite imminence to the market and even subsidization from the federal tax credit; the pervasive cost discrepancy with diesel may still need to be mitigated. For instance, the cost structure of biodiesel is based mainly on the cost of the feedstock input like soy oil and waste grease, the two main feedstocks discussed in this report. However, on a strictly cost basis, biodiesel from waste grease is much less than soy oil because the producer is paid to collect the grease. Using proper production can create a standardized biodiesel that passes all fuel specifications in testing[50]. Yet the many uncertainties involved with collecting and using waste grease for biodiesel influence the use of soy oil instead. Since waste grease collection can actually generate a revenue stream and thus lower variable costs, ensuring a significant portion of the total waste grease is available to producers is a major approach to make biodiesel cost competitive. City officials may be able to play a role to guarantee waste grease is allocated to biodiesel production. Although some forms of market based-policy, such as incentives to the restaurants, seem most effective, the exact method to carry this out will require further meetings between producers and city or county officials to formulate suggestions for implementation of this plan.

5. Streamline Zoning and Permitting

Once potential locations are cited and the community accepts biodiesel producers, the producers will be ready to begin the permitting phase. However zoning and permitting are problematic in West Oakland. This phase has proven to be one of the most preventative aspects for biodiesel start-ups in West Oakland. No one has ever been permitted in West Oakland to begin biodiesel production. The permitting process itself is very disconnected. For instance, a businessperson interested in putting up a McDonalds can find out what permits they need explicitly and expeditiously because this process has been replicated many times over. When a biodiesel producer wants to locate in West Oakland, it is a different story. It is difficult, if not nearly impossible to even find out what permits are needed, much less to get them. Producing in West Oakland can result in cheaper fuel, more end-use, and subsequently more emissions reductions. However, zoning and permitting are preventing the timely establishment of biodiesel production in West Oakland. At this point in time, it may take one or two full time management personnel, over a span of six months to a year to complete this process. This is both discouraging and costly. However, the City of Oakland, potential producers, and the community can take action to streamline the permitting and zoning process for sites that have been pre-examined by first establishing a list of permits and second facilitating acquisition of these permits in West Oakland.

6. Implement the use of Biodiesel

The next step is to institute biodiesel use. Three large consumers of diesel in and around West Oakland are the port, the USPS, and marine vessels. Being a landlord port, the Port of Oakland has limited means to impose the use of biodiesel. In addition to the Port of Oakland, a few other key diesel users can help propagate the use of biodiesel such as the Postal Service. In the near term the WOTRC should include the USPS in dialogue on testing biodiesel in their fleet. In the long term, if the tests are successful biodiesel can be used in many of the Postal Service Light and Heavy Duty Vehicles that currently use diesel. The added costs, like that noted by (Edgerley, 2005) with the City of Oakland, may be an economic constraint for the USPS to use biodiesel. Although biodiesel may be a way for the USPS to comply with EPACT. Lastly, the WOTRC should research and propose methods to provide offshore marine vessels biodiesel when they are within the effective emissions range. It is essential to collaborate and impose regulation using international shipping committees, ILWU, E.P.A., and CARB. A proposed legislation that subsidizes the infrastructure to provide ships offshore. The problem is California can only enforce regulations on emissions criteria within approximately 15 miles; however, the International Maritime Organization (IMO) regulates ships outside this range of offshore waters. Further dialogue between California legislators, US officials, and the IMO is warranted.

7. Recommendations for Biodiesel Producers

Large-scale production and use is required for biodiesel to truly make an impact on air pollution. If in fact a positive business relationship is established with the Port of Oakland, this partnership has the potential to set a model for the State of California and ports around the world. This means that producers must have strong business planning to support the demand driven by the Port of Oakland. Strong management, proper practices to prevent fuel contamination, and safety systems that ensure the community's environmental health and justice will promote successful production.

Getting down to business requires more planning than a backyard biodiesel operation. In a discussion with Steve Lautze in early 2006, Mr. Lautze noted that biodiesel businesses need to reflect forethought and preparation. Making biodiesel is something that almost anyone can do in the backyard. In the past, biodiesel has grown from a grassroots environmental statement, but it is now on the brink of a billion dollar national industry. Because it started as a grass roots movement, and it is easy to create, biodiesel has drawn the attention of environmentally-conscious people. Now that it has grown to be a significant alternative to diesel, it has captured the attention of business people too. However, most of the large-scale biodiesel operations I have investigated are not started by just anybody. Rather, venture capitalists and chemical experts are leading the way on large-scale plants and operations. Having technical expertise in running a large business can make or break a biodiesel start up. The following are essential for success in biodiesel production (Duff, 2004):

- Technical and Managerial Expertise
- Proprietary Technology

- Initial Investment (Sufficient funding to prove concept before venture capitalists will provide expansion funding)
- Decisions on Feedstock

Revisiting the previous example, many people that were making backyard biodiesel were also collecting waste grease to do so. This is a problem because, for one reason or another, most people were inconsistent, which made certain restaurants reluctant to agree to dispose of their oil with biodiesel producers. Large-scale biodiesel producers must overcome this hurdle. If waste grease producers agree to contract waste grease collection for biodiesel production, producers in turn should establish a positive reputation built on reliable, high quality collection. This is a second-order concern, but one that the producer must address with incentive to keep feedstock costs as low as possible.

8. Prevent Fuel Contamination

In biodiesel production there are a few main groups that handle the fuel. In a simple distribution process, the fuel will travel from the facility in trucks that will deliver it to the end-user where it will be stored in a tank. It is the responsibility of the producers first and foremost to ensure quality fuel from production to engine. Once the fuel changes hands the producer is still responsible for the fuel, it still has that producer's "name" on it. This means if the fuel changes hands and becomes contaminated after it leaves, the problem will affect the producer directly. Best management practices are required to alleviate potential for contamination in the fuel channel from production to distribution. This list is a helpful guide to prevent fuel contamination.

- Frequently drain the water from storage tanks, ensuring that vents and seals do not allow rainwater to enter
- Do not draw from the bottom of the tank to prevent from leaving the system
- In applications where the fuel is expected to come into contact with sufficient quantities of free water to support the growth of microorganisms, the fuel should be treated with a biocide to prevent their growth
- Taking the proper steps to ensure rapid sales of fuel to prevent oxidization
- Store fuel to avoid severe amounts of heat and light to prevent oxidization
- Use a biocide if fuel is stored for long periods of time (over 6 months)

9. Ensure the Safety of Community

It is the responsibility of the producers to ensure the safety of the residents around the production facility. There are risks when raw materials are transported into the community. Methanol and the catalyst used in production are both volatile chemicals. Methanol is alcohol and combusts at much lower temperatures than biodiesel itself. Biodiesel production will also attract traffic into the community. So, producers should consider what fuel is burned in the trucks in which they transport various products. As noted in Table 4.2 a 5 million gallon per year facility would have 11 trucks going in and out per day. In talking with most producers, I found they plan to use biodiesel, at least in the trucks that distribute the end product.

Phase 3: Ongoing Steps to Support the Success of Biodiesel Implementation

10. Stakeholders Must Stay Involved in Discussions Around the Federal Excise Tax Credit.

Federal Tax Credits help make biodiesel cost competitive with diesel. However, these tax credits are only guaranteed through 2008. The credits were established as part of the American JOBS Creation Act of 2004 (H.R. 4520), and President Bush signed the bill into law in October 2004. The problem is that the admonishment of this exogenous variable can result in severe cost structure breakdown in biodiesel production up to $1 per gallon[51]. There are simple ways to address this issue. In the near term, the WOTRC should have as many people as willing to write a brief letter to support the extension of the credits through December 10, 2010, and address the letter to Senator Dianne Feinstein either by email or mail. (See info below) This recommendation is an ongoing task, although it is one of the first items to address. If possible, as many as willing should continue to write letters after every WOTRC meeting.

Write a letter

Senator Dianne Feinstein
United States Senate
331 Hart Senate Office Building
Washington, DC 20510

E-Mail the Senator

All electronic mail sent is tallied and your opinions are noted and appreciated. If you wish a response to your email, please include your California postal mailing address in the text of your message. Due to the volume of email we receive, we are only able to respond to messages that contain a California postal address. Please ensure that your email is in plain text format and does not include any attachments.

E-mail the Senator at the following link:
http://www.senate.gov/~feinstein/email.html.

The extension of the biodiesel federal excise tax credit requires the agreement between Congress and the Senate, which will include the tax credit in an upcoming bill.

See Section 4.4 and Fig. 4.2, entitled exogenous variables, which explains what is necessary for biodiesel to remain competitive if the federal excise tax credit is absolved.

11. Conduct Dialogue with East Bay Municipal Utility District (EBMUD)

There is about 3 times more trap grease[52] per person per year than waste grease. , a lot of which ends up at EBMUD. The problem with trap grease is that it gets mixed into the waste water system, making it hard to decontaminate for biodiesel use. However, recently EBMUD has been able to recover trap grease in the water system by separating it from the waste water. Engaging EBMUD in WOTRC meetings is the first step in deciphering the potential role they can have for biodiesel production in West Oakland. In the longer term, this grease needs to be quantified and plans determined on the use of the grease. One main goal is to decide if EBMUD can work with producers in the community as cited in the previous section on West Oakland production. It does in fact make sense to use this grease for biodiesel[53]. However, extra steps to decontaminate this grease are required before this grease converted into biodiesel

12. NOx reduction and CARB certification

Although biodiesel is considered an alterative fuel at a federal level it is not CARB certified. The National Biodiesel Board (NBB) is working with CARB to create and fulfill criteria for biodiesel certification. One major thing that can be done in West Oakland is to prove that NOx can successfully be reduced in trial runs. The first step in this process requires subsidization of the additive cost, plus a brief environmental assessment of the additive itself. NOx solutions are thoroughly discussed in the section on NOx emissions. Cetane enhancing additives in biodiesel are successful in reducing NOx emissions below certification fuel level. According to an EPA emissions calculator

NOx emissions from B100 increase 22%, and NOx emissions from B20 increase 4%. However, DTBP and EHN can reduce NOx emissions below certification fuel level. The problem with DTBP is that it adds an additional marginal cost of about $0.16 per gallon of biodiesel. Reducing the NOx emissions below certification fuel levels may be one means to CARB certification.

Endnotes:

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1. Transesterification (also called alcoholysis) is the most commonly used in current biodiesel production method.
2. 1/5 was calculated by the total combined container traffic from the Ports of LA and Long Beach from 2003, and divided by the total container traffic in Oakland. The statistics are from U.S. Port Authority.
3. This statement is from the An Oakland tribune article entitled *Oakland's Ports grows faster than any other on West Coast,* published January 24, 2006, yet it was unclear if was from an interview with the Oakland tribune or a public statement. The amount for other reductions was not included.
4. Seattle Biodiesel and one port terminal in the Port of Seattle have a contract for 800,000 gallons of biodiesel. The use of biodiesel in the terminal will begin with B5 blend and ramp up to B20 in 3 months. Seattle biofuels website.
5. The 6 criteria pollutants are lead, sulfur dioxides, NOx, carbon monoxide, particulate matter, and ozone. 100% biodiesel (B100) can reduce PM emissions 37%, CO 41%, and Hydrocarbons 69%.This Fig. does not include sulfates PAH, and VOC's.
6. In a recent study the E.P.A stated emissions reductions were significantly higher except for NOx which was significantly lower than the emissions used here from the most recent E.P.A. calculator at www.westcoastdeisel.org.
7. For example the difference in total emissions between B5 and B20 can be calculated by choosing a value for gallons on the B5 curve and subtracting the emissions on the B20 curve at the same gallons value.
8. To understand the concept of market penetration further, let's discuss criteria that investors use when analyzing a market. In business terms, there is a market and a target market. A biodiesel producer might aim to replace every gallon of diesel with biodiesel, making all diesel users the potential market. However, this is a long-term objective, and a fairly unrealistic goal for one producer to achieve in the short run. The target market for a biodiesel producer reflects that portion of the diesel market that will actually use a producer's biodiesel. When investors look at a business plan they want a target market that can be penetrated no more than five years away from the start of the company. Hence, the target market is a realistic market that can be penetrated within a limited timeframe.
9. Distillate fuel is categorized by diesel and some forms heating oil. On highway use is typically diesel #2.
10. Section 10 CFR Part 490.
11. American ports currently handle about 2 billion tons annually, (Hricko, 2005).
12. This statistics is from maritime facts and Fig. www.portoakland.com, 2004.
13. Before Peter Peirs became head of the hazardous materials, he was a captain on container ships for over 20 years. This information came from a conversation he and I had regarding biodiesel in late February 2006.
14. Another future option is canola oil from the northwest. Canola oil crushing plants are part of a large sustainable feedstock development plan established by Seattle Biodiesel.
15. The owner of this technology is slowly implementing it, but wants to do so at a small scale, over a longer period of time, so that it can be monitored.
16. There are limitations to this research was brought up in a meeting with Nth Power Venture Capital Firm. According to the managing director, market research of this sort can be misleading. That is over the phone the interviewed is disconnected from commitment, and is likely to try and please the person asking the questions. In this case, the person interviewed often neglects the true assessment of what that means to their business in real costs and action. Letters of intention to supply biodiesel producers with waste grease are much more substantial than over the phone market research.
17. The microeconomic discussion begins with the importance of economies of scale. One way a producer can lower overall production costs is producing at economies of scale. The

economist, George V. Thompson in 1954, described economies of scale in the early auto industry with the standardization of parts. Economics dictates, once greater economies of scale are reached marginal costs decrease. Therefore, feedstock can increase with less impact on the producer because overall marginal production costs are lower. Subsequently, biodiesel retail prices remain competitive with conventional diesel. That is, as production scales grow the marginal costs of production decrease. That means the producer gets more profit per unit gallon produced. Importing soy oil from the Midwest can help explain economies of scale. The price of large soy oil supplies and the distance the source supplies are from West Oakland are vital components of marginal production costs. The less soy oil purchased the more each gallon costs. The more soy oil purchased at once the better deal the producer gets. Reaching economies of scale with waste grease can help producer gain higher profit margins using soy oil, when it comes time. This is economies of scale. However, no matter how much fuel is produced it obviously must be sold. Reaching economies of scale requires a large demand to purchase the biofuel produced.

18. According to The Executive Summary from the Biodiesel Handbook, during either process complete reaction to the mono alkyl esters, the removal of free glycerin, the removal of residual catalyst, the removal of reactant alcohol, and the absence of free fatty acids are essential in determining the quality of the fuel
19. Additional statistics from this report are located in the appendices of this report
20. New technology allows the use of multiple feedstocks at once, however it is proprietary and used only by Biodiesel of Las Vegas. Developed by Caltech Engineers.
21. Considering investment of 2.5 million in start-up investment and considering a return on investment between 25% and 40%. Break even point is in year three in the worst case scenario.
22. (Duff, 2004) suggest that having a Return on Investment (ROI) proposition of 25-40% is imperative to attract funding from serious investors. ROI is typically based on a 5 year valuation, at which during that point in time, the ROI can be at least partially redeemed by the investor**.**
23. In addition to these regional initiatives, the federal Renewable Portfolio Standards (RPS), a market based incentive program to stimulate alternative energy use, call for 7.5 billion gallon of biofuel use by 2012.
24. After biodiesel is produced it must be mixed or blended with diesel. This tax credit typically goes to the blender, because the federal government requires that at least 1% diesel is blended with 100% biodiesel to acquire the credit.
25. Total production costs including feedstock are about $2.00 from waste grease.
26. EIA on-highway diesel was $2.78 per gallon in April 2006. Retail was about $2.55.
27. Opacity is a measure of black soot, but not specific emissions. Increased opacity in the initial testing is something might be expected to be seen whether or not emissions were actually reduced.
28. Bailey et al 1999 states that if two or more double bonds are present in one fatty acid chain, the tendency to oxidize is greater. This can be explained by the increase in the number of double bonds. The linoleic acid, with two double bonds, oxidizes more readily than oleic acid with only one double bond. Oxidation also enhances in the strong heat and light, and if oxygen is present oxidization will occur.
29. In other cases actual microbial alteration of sulfur initiates corrosion which leads to plugging and sedimentation.
30. The fact that this additional water is bound to the fuel and not available for microbial growth may justify this increase. The increase in the activity of microorganisms on biodiesel, especially molds, is also reason for concern. This will have an adverse effect on the biodegradability of the fuel.
31. It is suggested to use a biocide when storing over six months.
32. NREL subcontracted the Colorado School of Mines (CSM) to conduct a series of six studies on biodiesel emissions.

33. NREL report 2 out of 6, The Effect of Biodiesel Composition on Engine Emissions from a DDC Series 60 Diesel Engine, analyzes biodiesel emissions from different feedstocks compared to California No. 2 certification diesel.
34. However, the study found highly saturated esters methyl palmitate, methyl laurate, ethyl and methyl stearate, and ethyl from hydrogenated soybean oil all had no NOx increase without any fuel modification The reasons this occurred can be attributed to chemical structure (see following section).
35. NREL report 2 states an iodine number of 38 are typical of a NOx neutral fuel.
36. Double bonds in pre-combustion or combustion chemistry may have an affect on increased NOx, as it was found, increasing number of olefinic (C=C) bonds is directly related to increased NOx emissions. There relationship between double bonds and less NOx production was observed with stearate based fuels which have no double bonds and produced significantly less NOx than certification diesel.
37. Please refer to Graboski et al 2003, NREL report 6 for full explanation of testing methods.
38. Environmental Considerations must be assessed when using DTBP on a large scale.
39. The six cylinder, four stroke engine is nominally rated at 345 bhp (257 kW) at 1800 rpm and is electronically controlled (DDEC-II), direct injected, turbocharged, and inter-cooled (31). This is the engine model specified in California Code of Regulations Title 13 section 2282, subsection g for certification testing of diesel fuels. It is important to note that newer engines have shown strong emissions decreases relative to older models across multiple studies (McCormick et al 2003).
40. Many of these methods worked for each fuel, some only for B20.
41. The use of antioxidants in general is worthy of further study.
42. No combination of biodiesel with certification fuel and fuel additives produced NOx emissions levels below that observed for a 10% aromatic fuel, suggesting that CARB certification using a 30% aromatic base fuel is not possible. This finding is significant at 95% confidence or greater.
43. This may indicate that cetane improvers act largely to lower the NOx produced during burning of the petroleum diesel fuel. This result represents a statistically significant NOx reduction, but it is still well above the certification fuel level. All cases refer to soy and waste grease.
44. EIA high bound estimate is 475 million gallons by 2010, the low estimate is approximately 50 million gallons.
45. Steve Lautze has made a verbal commitment to WOEIP to take part in this tour.
46. This type of electricity can be produced from any number of sources but the majority is coal fire power plants which emit sulfur dioxides responsible for air pollution and acid rain.
47. Ideally there will a total package to get users to switch which includes engine longevity and economic incentives, such as cheap fuel.
48. For instance, the recent proposal of Dr. James Fine’s GOFI project plans on conducting grass roots works at the scales of OMSS, and WOEIP is progressing on this topic.
49. The goal is to retain the information from the survey quickly. Handing out the survey and relying on those surveyed to send it in may result in less response. Also, once many end users have tested biodiesel a follow –up survey can determine the success rate of biodiesel in West Oakland. This may be 1-2 years after summer 2006.
50. Biodiesel producers have the responsibility to market their fuel. Nevertheless, this should not delay the use of the fuel by end-users. The educational process is intended to prime the market, and dispel end users’ reluctance to change. However, the implementation of biodiesel use in West Oakland does not have to wait for production. General information can and should come from public grassroots efforts, with goals to have at least one information session within six months of this report. Then it is also the responsibility of biodiesel producers to take this information to the next level, perhaps in a collaborative effort with the WOTRC. For instance, the initial grassroots movement may inform truck drivers that ULSD increase wear and tear on their engines. Then biodiesel producers come along and provide the

statistics calculating how long a life biodiesel will provide for a specific year model engine compared to ULSD, providing a true cost benefit analysis for their customer. Marketing and sales on the behalf of the producers required to actually get truckers to use the fuel. However, having the foreground of information planted by the community increases the interest truckers have in biodiesel. Essentially once the interest is there, the barrier to implementation is reduced, establishing a more receptive market when production begins. Certain mechanical requirements must be fulfilled when converting to biodiesel. It is the liability of anyone who is distributing the fuel to the end-user to inform the end-user about the small requirement. For instance, in a test phase, the facilitator of the test phase must ensure that the proper filter changes are administered at the proper frequency. (Approximately once per month if B20.) Also, producers who sell their fuel directly must also educate the end-users about the proper mechanical requirements specific to their equipment. This will ensure that the transition of the end-user to biodiesel is smooth. Each piece of equipment is different. This may require significant research on the part of the producer if they plan to provide fuel to different sorts of equipment. There is though, ample data for trucks using B20 and B100.

51. Gelling can occur with waste grease at low temperatures. The temps range based on the way the fuel is produced. Fir instance Biodiesel of Las Vegas can produce a waste grease based fuel that gels near 0 degrees F.
52. Waste grease tax credit is $0.05 per percent biodiesel mixed with diesel
53. Using trap grease for biodiesel is a new technology that will help close the loop in waste grease disposal and clean air, and increases the supply an estimated two fold.

8.) List of People Contacted:

Anne Whittington	Environmental Supervisor Port of Oakland	Phone	2006
Curtis Wright	**Imperial Western** Products	Phone	2006
Jennifer Edegerley	City of Oakland	Phone	2006
Dr. James Fine	Air Quality Expert	Interview	2006
Dr. Jack Lendvay	Dept. Chair of Environmental Science, USF	Interview	2006
Jennifer Radtke	Owner Biofuel Oasis	Conference	2006
Tim Leong	Environmental Supervisor Port of Oakland	Phone	2006
Larry Louie	Assistant Dean of Masuang School of Business	Phone	2006
Steve Lautze	City of Oakland Economic Director	Phone	2006
Ben Maese	Owner 3C Ventures	Phone	2006
Peter Peirs	Head of Hazardous Materials	Interview	2006
Jim Cross	Cross Petroleum	Phone	2006

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Maps:

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Newspaper Article:

Oakland tribune article entitled *Oakland's Ports grows faster than any other on West Coast,* published January 24, 2006.

Memorandum:

To: Honorable Mayor and Members of the City Council
From: Phil Kamlarz, City Manager
Submitted by: Claudette Ford, Acting Director, Public Works Department
Subject: Follow Up on Use of Biodiesel

APPENDIX

Diesel Related Health Problems in West Oakland

Toxic diesel emissions, in and around the community of West Oakland, burden the community with intractable health problems. Numerous scientific studies link diesel emissions to lung cancer, reproductive system damage, asthma, asthma aggravation, and respiratory illness. The health problems from diesel emissions in West Oakland are discussed through the use of the following reports, survey, and articles. “Clearing the Air” and “Neighborhood Knowledge for Change” are reports by the West Oakland Environmental Indicators Project (WOEIP) in collaborations with Pacific Institute and the community of West Oakland. In addition, a number of community organizations conducted a survey on a small sample size of the West Oakland population. The survey determined air quality was a major problem for the 52 households surveyed. This section also reviews a report entitled “Children’s exposure to Diesel Exhaust on School Buses” by (Wargo, 2002) from Yale University, to provide a broader spectrum of diesel related health problems.

Diesel Related Health Problems

Air pollution has short term and long-term exposure effects that are especially magnified in elderly people and young children. The following sections summarize short term and long-term health effects, for both people with asthma and without asthma, that are caused by diesel emissions (Wargo, 2002).

Asthmatics:

- Adverse respiratory health effects among asthmatics
- Nitrous dioxides induce airflow limitation in female asthmatics

- Asthmatics had increased reaction to allergen after exposure to PM 2.5 at levels more than 100ug/m3

Non-Asthmatics and Asthmatics:

- Truck traffic intensity is directly "associated with chronic respiratory symptoms"
- Irritation of the eyes and nose
- Hyperventilation
- Declined peak respiratory flow during high PM episodes
- Coughing, wheezing
- Decreased lung function (Wargo, 2002)

Long term Health Problems

- Benzene, a major component of diesel, is a know carcinogen
- Components of diesel are genotoxic, mutagenic, and inflame airways
- The California South Coast Air Quality Management District recently estimated that approximately 71% of the cancer risk from air pollution is from diesel exhaust
- 18-76% increases bladder cancer risk associated with diesel exposure; based primarily on truck drivers, rail workers, bus drivers, and shipyard workers
- Diesel exhaust is the 6th most potent carcinogenic substance reviewed by the state of California's Scientific Review Panel

Students spend on average 180 hours on school buses and are extremely subject to the long term health problems caused by diesel emissions (Wargo, 2002).

Chemicals in Diesel Exhaust Listed by The California Air Resources Board as Toxic Air Contaminants

acetaldehyde
acrolein
aniline
antimony compounds
arsenic
benzene
beryllium compounds
biphenyl
bis[2-ethylhexyl]phthalate
1,3-butadiene
cadmium
chlorine
chlorobenzene
chromium compounds
cobalt compounds
cresol isomers
cyanide compounds
dioxins and dibenzofurans
dibutylphthalate
ethyl benzene

formaldehyde
hexane
inorganic lead
manganese compounds
mercury compounds
methanol
methyl ethyl ketone
naphthalene
nickel
4-nitrobiphenyl
phenol
phosphorus
Polycyclic Aromatic Hydrocarbons
propionaldehyde
selenium compounds
styrene
toluene
xylene isomers and mixtures

o-xylenes
m-xylenes
p-xylenes

West Oakland Health Problems:

West Oakland is a community in Alameda County with approximately 22,000 residents. The residents in West Oakland have similar demographics to the rest of Alameda County, but there is one main distinguishing factor. West Oakland is trapped in a valley of diesel emissions, wedged between freeways, and bordered by the Port of Oakland telescoping diesel exhaust from buses, trains, trucks, ships, and marine port equipment. The following summarizes diesel emission characteristics and subsequent effects in West Oakland.

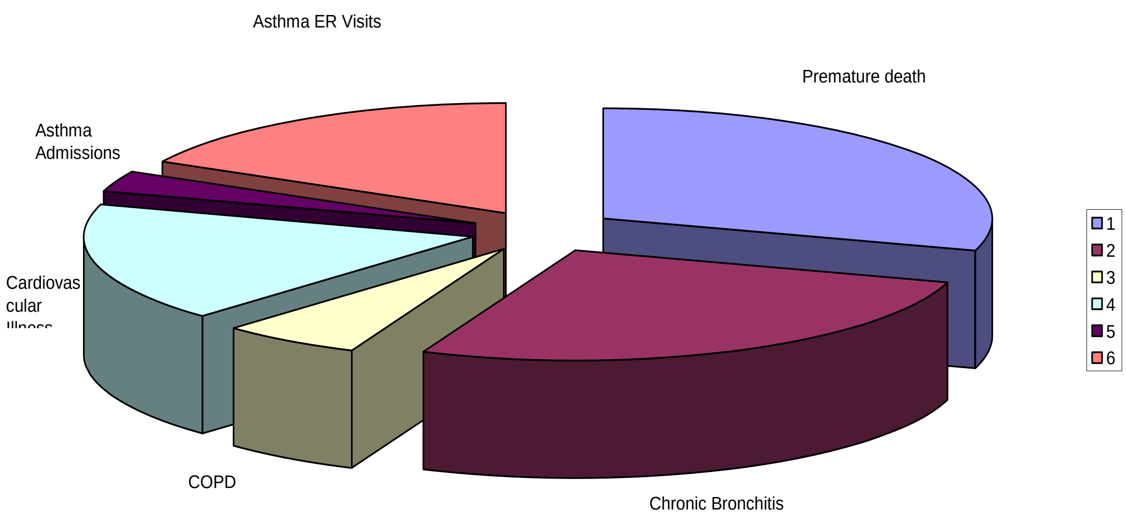
- Residents are exposed to 5 times more diesel particulates residents in other parts of Oakland
- Over 9 pounds of diesel particulate matter is emitted per person per year in West Oakland
- The rate for asthma in West Oakland is 7 times higher than the rest of California
- Some West Oakland residents are exposed to roughly five times more diesel particulates than residents in other parts of Oakland
- West Oakland residents may have an increased risk of one extra cancer per 1,000 residents due to diesel particulate exposure over a lifetime
- It would require 127, 627 cars to produce equivalent soot to the number of trucks in West Oakland (approximately 2,000 trucks on any given day)
- These health problems cause people to miss school and work
- Approximately 80 – 95% percent of particles in diesel exhaust are less than 1 micron in size, the fine and ultra-fine particles provide a delivery service to the lung for hazardous particles and gases
- The doubling of container throughput at the port will generate an estimated 22,000 truck trips per day

General Health Costs

Diesel related health effects are vast. Medical costs associated with health problems from diesel often perpetuate an already degraded social situation in communities such as West Oakland. In the San Francisco Bay Area, the Union of Concerned Scientists reports health costs from diesel exhaust in 2004 totaling over $3.5 million. Fig. 1.1 depicts health incidences by type, illustrating percentages of costs caused by diesel. The various incidences include asthma ER visits, asthma admissions to hospitals, cardiovascular problems, chronic bronchitis, and premature deaths. Premature deaths constitute the highest costs associated with diesel emissions.

Fig. 1.1

San Francisco Bay Area Health Incidenses From Diesel Exhaust 2004



Source: Union of Concerned Scientists, Sick of Soot

Fig. 1.1 displays the percentile break down of health incidences in the Bay Area Air Basin from diesel exhaust in 2004. The total costs were an estimated $3.5 million.

West Oakland Health Costs

West Oakland experiences disproportionate health costs associated with diesel emissions. In 1998, the Neighborhood Knowledge for Change reports indicated rates of 899 out of 100,000 children and 405 out of 100,000 of the remaining population were hospitalized in West Oakland because of asthma. An alternate survey from the Pacific Institute found that 64% of children were not insured, and 40% of the remaining population was not insured. A simple model was created to calculate West Oakland health costs associated with hospitalization for asthma alone. Asthma hospitalization costs were estimated at nearly $800,000 for West Oakland residents per year. This report will discuss the amounts of different diesel pollutants that biodiesel can offset. First, the production and emission chemistry behind biodiesel emissions is explained so the reader may have a complete understanding of how biodiesel reduces pollution.

10.) Appendix

*Total Emission Reductions in Pounds**					
Total Pounds Produced per Pollutant @ B5 (High Demand)					
Nox	**Particulates**	**ROG**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**
99,146,365.50	**2,272,809.18**	**2,876,259.75**	**87,415,737.50**		
Total Pounds Reduced per Pollutant @B5 (High Demand)					
Nox	**Particulates**	**ROG/HC??**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**
4,377.32	**-451.55**	**-1,333.37**	**-19,297.07**		
Total Pounds Produced per Pollutant @B20(High Demand)					
Nox	**Particulates**	**ROG**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**
396,585,462.00	**9,091,236.70**	**11,505,039.00**	**349,662,950.00**		
Total Pounds Reduced per Pollutant @B20(High Demand)					
Nox	**Particulates**	**ROG**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**
17,509.29	**-1,806.21**	**-5,333.46**	**-77,188.29**		
Total Pounds Produced per Pollutant @B5 (Low Demand)					
Nox	**Particulates**	**ROG**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**

28,763,391.43	**659,365.57**	**834,432.86**	**25,360,214.29**		
Total Pounds Reduced per Pollutant @B5 (Low Demand)					
Nox	**Particulates**	**ROG/HC??**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**
29,275,163.91	**-131.00**	**-386.82**	**-5,598.28**		
Total Pounds Produced per Pollutant @B20(Low Demand)					
Nox	**Particulates**	**ROG**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**
2,637,462.29	3,337,731.43	101,440,857.14	101,440,857.14		
Total Pounds Reduced per Pollutant @B20(Low Demand)					
Nox	**Particulates**	**ROG**	**Carbon Monoxide**	**Sulfates**	**Nox w/additive**
52.40	**-663.13**	**-47,025.56**	**-22,393.13**		

Port of Oakland Diesel Fuel Demand

Comparatives

Port of Allegany	10,000,000		
		truck type per distance	miles per day
Customers Private Trucks			
	Long Haul	**400**	**40,000**
	Short Haul	**1,600**	**38,400**
Tugboats		**50**	**20**
Ships		**10,000**	

Port Equipment	terminals	**equip per terminal**	**total equip per port**	**total miles day/equip**
Generators (no mileage)	11	**100**	**1,100**	
forklifts	11	**20**	**220**	
hostelers	11	**20**	**220**	

total gallons for port equipment				
sum total	17,353,000.00			
b20 blend required gallons	3,470,600.00	4,511,780.00		
b5 blend required	867,650.00	1127945		
			3.78	6

NREL Report 2 Tables

Table 1. Properties of certification diesel fuel Lot D-434 used as reference in this study.

Property	*Lot D-434*	*ASTM Method*
API Gravity	36.28	D-287
Viscosity, cs 40°C	2.5	D-445
Net BTU/lb	18456	D-3338
Cetane Number	46.0	D-613
Carbon, wt%	86.6	D-5291
Hydrogen, wt%	13.4	D-5291
Oxygen, wt%	0	D-5291
Sulfur, ppm	300	D-2622
Nitrogen, ppm	--	D-4629
IBP, F	353.9	D-86
T50, F	498.7	D-86
T90, F	583.7	D-86
EP, F	646.4	D-86
Aromatics, vol%	29.2	D-1319
Olefins, vol%	2.0	D-1319
Saturates, vol%	68.8	D-1319

Our original contract with NREL called for making (or acquiring) and testing 18 fuels. As Table 2 shows, 20 fuels were prepared by CSM. There was some deviation from the original plan. The methyl soyester employed was a commercially available biodiesel known as "Soyagold." This methyl ester was transesterified with ethanol to prepare the ethyl soyester. Only a small quantity of linolenic acid was available from the supplier, and this was used to prepare most of the methyl linolenate. To satisfy the need for tri-unsaturates, linseed oil was used as an additional unsaturated fatty acid, to supply some fraction of the methyl linolenate. We originally planned to prepare ethyl linolenate, however this fuel was made entirely from linseed oil, as was the methyl linseed ester originally specified for blends of stearate and linolenate esters. We also originally planned to produce highly oxidized samples of methyl and ethyl linolenate by oxidation in the laboratory. However, we had 50 gallons of highly oxidized (peroxide value of about 2000) methyl soy ester stored in our lab, and utilized this material instead. This material had become oxidized over several years of storage at room temperature. Oxidized ethyl esters were prepared by transesterification of this material with ethanol.

Table 2. List of biodiesel fuels tested in this study, actual test sequence in Appendix A (LFFAG=low free fatty acid grease, HFFAG=high free fatty acid grease).

Fuels Tested
Supplied by IGT
Methyl Soy
Edible Methyl Tallow
Inedible Methyl Tallow
Methyl Canola
Methyl Lard
Methyl LFFAG
Methyl HFFAG
B20 Inedible Methyl Tallow
B20 Methyl Soy
B20 Methyl LFFAG
Supplied by ARS
Methyl Soapstock Ester
B-20 Methyl Soapstock Ester
Prepared at CSM
Methyl Laurate
Methyl Palmitate
Methyl Stearate
Ethyl Stearate
Methyl Oleate
Ethyl Oleate
Methyl Linoleate
Ethyl Linoleate
Methyl Linolenate
Ethyl Linseed
Methyl Soy (Soyagold)
Methyl Hydrogenated Soy
Ethyl Soy
Ethyl Hydrogenated Soy
2:1 Methyl Stearate:Methyl Linseed
1:2 Methyl Sterate:Methyl Linseed
Oxidized Methyl Soy
Oxidized Ethyl Soy
High Acid Number Methyl Oleate
High Glyceride Ethyl Soy

Test Engine:

The engine is a 1991 calibration, production model loaned by the Detroit Diesel Corporation. The six cylinder, four stroke engine is nominally rated at 345 bhp (257 kW) at 1800 rpm and is electronically controlled (DDEC-II), direct injected, turbocharged, and intercooled. Engine specifications are listed in Table 5.

Table 5. DDC Series 60 engine specifications and mapping parameters.

Parameter	
Serial Number	6R-544
Displacement	11.1 L
Rated Speed/Horsepower	1800 rpm/345 bhp
Max Torque Speed/Max Torque	1200 rpm/1335 ft-lb
Idle Speed/Citt	600 rpm/0 ft-lb
High Idle Speed	1940 rpm
Intake Depression	-16 ± 1 in H_2O
Backpressure	32.6 ± 3 in H_2O
Aftercooler Dp	40 ± 3 in H_2O
Intake Manifold Temperature	44±2°C

Table 6. Analytical results for neat biodiesels and B-20 blends.

Sample	Carbon wt%	Oxygen wt%	Hydrogen wt%	Cetane Number	Heat of Combustion,btu/lb Gross	Heat of Combustion,btu/lb Net
Methyl Soy, Neat	76.25	11.16	12.59	47.2/59*	17130	15940
Edible Methyl Tallow, Neat	75.15	11.74	13.11	62.9/64.8*	17120	15881
Inedible Methyl Tallow, Neat	75.30	11.08	13.62	61.7/54.3*	17128	15841
Methyl Canola, Neat	76.12	11.04	12.84	55.0/53.9*	17074	15861
Methyl Lard, Neat	75.03	11.82	13.15	63.6/NA*	17084	15841
Methyl LFFAG, Neat	75.71	11.10	13.19	57.8/52.2*	17133	15887
Methyl HFFAG, Neat	76.06	11.28	12.89	52.9/53.2*	16928	15710
B20 Inedible Methyl Tallow	83.43	2.73	13.84	49.1**		17933**
B20 Methyl Soy	83.51	2.52	13.97	46.2**		17953**
B20 Methyl LFFAG	83.65	2.31	14.04	48.4**		17942**

* Reported by IGT

** Calculated assuming linear blending by volume or weight fraction.

Validation of Properties and Comparison with the Literature

Iodine Number:

Iodine number is an easily measured property that provides information on chemical composition. This property is measured by titrating the olefinic bonds in the fuel to establish the weight of iodine required to fully saturate the molecule. Figure 1 shows the relationship between measured iodine number by ASTM 5550 and the calculated iodine number from the GC/MS analyses. The agreement is excellent considering the accuracy of the speciation technique employed. The good agreement substantiates both the speciation results and measured iodine numbers.

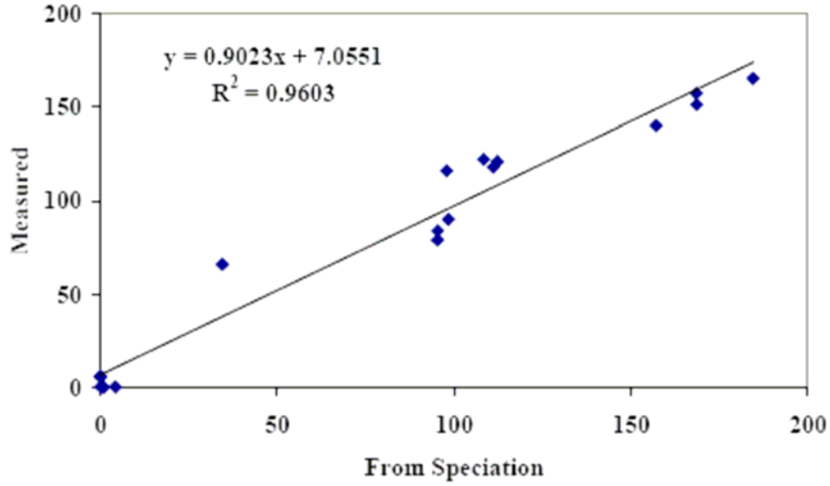


Figure 1. Comparison of measured iodine number with value calculated from fatty acid speciation data.

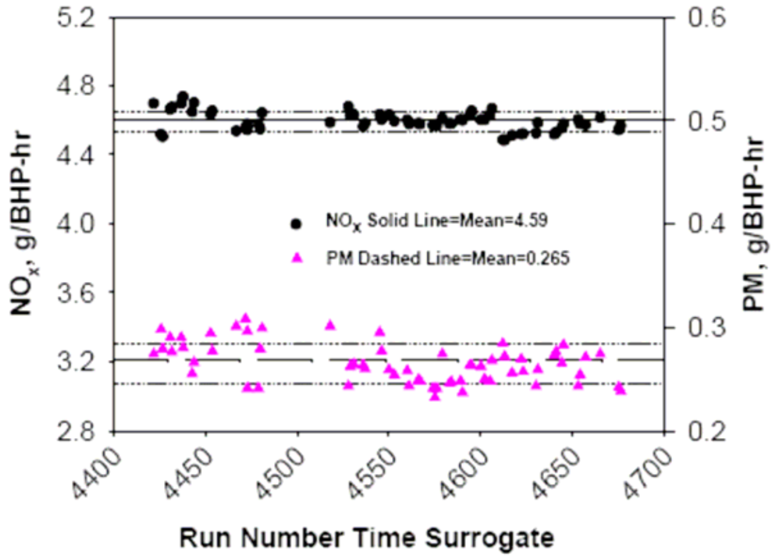


Figure 4. NO_x and PM emissions results for certification fuel runs performed over the study.

Tables 12 and 13 present descriptive statistics for the certification fuel runs. The median and mean are very close, suggesting a normal distribution and that the majority of the variance is due to random fluctuations in the data and not a large time series effect. During testing, the engine head cracked and needed to be replaced. The crack occurred between certification fuel runs 4454 and 4467. Between certification fuel runs 4481 and 4513 maintenance was performed on the engine dynamometer. Tables 14 and 15 compare NO_x and PM before run 4454 and after run 4513 using a t-Test to determine whether the two populations are the same. In both cases, we conclude that there was a small but statistically significant shift in emissions. However, we cannot conclude that the change is a result of mechanical effects as drift could produce a similar result.

Port of Oakland Diesel Fuel Demand

Comparatives

Port of Allegany 10,000,000

		truck type per distance	miles per day
Customers Private Trucks			
	Long Haul	**400**	**40,000**
	Short Haul	**1,600**	**38,400**
Tugboats			**20**

		50			
Ships		**10,000**			
Port Equipment	terminals	**equip per terminal**	**total equip per port**	**total miles day/equip**
Generators (no mileage)	11	**100**	**1,100**	
forklifts	11	**20**	**220**	
hostelers	11	**20**	**220**	
total gallons for port equipment				
sum total	17,353,000.00			
b20 blend required gallons	3,470,600.00	4,511,780.00		
b5 blend required	867,650.00	1127945		
				3.78	6

Tables from (Duff, 2004).

Oil Extraction and Biodiesel Production Plant Statistics			
Production Inputs	**3 MMGY**	**5 MMGY**	**10 MMGY**
Oilseeds (tons/yr)	37,500	63,000	126,000
Oilseeds (bu/yr)	1,250,000	2,100,000	4,200,000
Water (gal/yr)	3,720,000	6,200,000	12,400,000
Electricity (kWh/yr)	4,500,000	7,500,000	15,000,000
Natural Gas (MCF/yr)	28,050	46,750	93,500
Chemicals & catalysts (tons/yr)	1,656	2,782	5,564
Production Outputs	**3 MMGY**	**5 MMGY**	**10 MMGY**
Oilseed meal yield (tons/yr)	26,250	43,750	87,500
FAME (Biodiesel) (gal/yr)	3,000,000	5,000,000	10,000,000
Soapstock (tons/yr)	1,937	3,228	6,456
Wastewater (gal/yr)	1,636,800	2,728,000	5,456,000
Incoming Transportation	**3 MMGY**	**5 MMGY**	**10 MMGY**
Oilseed (Trucks/yr)	938	1575	3150
Chemicals & catalysts (Trucks/yr)	42	70	70
Total Trucks Inbound per Day	3	5	9
Total Trucks Inbound per Year	980	1645	3220
Outgoing Transportation	**3 MMGY**	**5 MMGY**	**10 MMGY**
Degummed Oil (trucks/yr)	600	1000	2000
Oilseed Meal (trucks/yr)	656	1094	2188
Gums (trucks/yr)	97	161	323
Total Trucks Outbound per Day	4	6	13
Total Trucks Outbound per Year	1353	2255	4510
Outgoing Transportation	**3 MMGY**	**5 MMGY**	**10 MMGY**
Total Trucks per Day	7	11	22
Total Trucks per Year	2333	3900	7730

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