(ENVIRONMENTAL BENEFICIAL ASPECT OF BIO DIESEL)

By
ANJU PANWAR
Roll No. R070207003

College of Engineering
University of Petroleum & Energy Studies
Dehradun
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ENVIRONMENTAL BENEFICIAL ASPECT OF BIO DIESEL

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By
(Anju Panwar)

Under the guidance of

Dr. R.P Badoni
UPES
Dehradun

Approved

....
Dean

College of Engineering
University of Petroleum & Energy Studies
Dehradun
May, 2008

CERTIFICATE

This is to certify that the work contained in this thesis titled "ENVIRONMENTAL BENEFICIAL ASPECT OF BIO DIESEL" has been carried out by Anju Panwar under my/our supervision and has not been submitted elsewhere for a degree.

Dr. R.P Badoni
UPES
Dehradun

Abstract

Biodiesel is noteworthy for its similarity to petroleum-derived diesel fuel, while at the same time having negligible sulfur and ash content. Bioethanol has only about 70% the heating value of petroleum distillates such as gasoline, but its sulfur and ash contents are also very low. Both of these liquid fuels have lower vapor pressure and flammability than their petroleum-based competitors – an advantage in some cases (e.g. use in confined spaces such as mines) but a disadvantage in others (e.g. engine starting at cold temperatures.

Despite their wide range of possible sources, biomass feedstock are remarkably uniform in many of their fuel properties, compared with feedstocks such as coal or petroleum. For example, there are many kinds of coals whose gross heating value ranges from 20 to 30 GJ/T (giga joules per metric tonne). However, nearly all kinds of biomass feedstocks destined for combustion fall in the range 15-19 GJ/T. For most agricultural residues, the heating values are even more uniform – about 15-17 GJ/tonne (6450-7300 Btu/lb); the values for most woody materials are 18-19 GJ/tonne (7750-8200 Btu/lb).

Classes of Biofuels

Solid Biofuels

There are many forms of solid biomass that are combustible as a fuel such as:

- Wood
- Straw and other dried plants
- Animal waste such as poultry droppings or cattle dung
- Crops such as maize, rice, soybean, peanut and cotton (usually just the husks or shells) & sugarcane- or agave-derived bagasse.

Liquid Biofuels

There are also a number of liquid forms of biomass that can be used as a fuel:

- Bioalcohols
- Ethanol – usually produced from sugarcane, also from corn
- Methanol, which is currently produced from natural gas, can also be produced from biomass. The methanol economy is an interesting alternative to the hydrogen economy

- Butanol, formed by A.B.E. fermentation (Acetone, Butanol Ethanol) and experimental modifications of the ABE process show potentially high net energy gains. Butanol can be burned "straight" in existing gasoline engines (without modification to the engine or car), produces more energy and is less corrosive and less water soluble than ethanol, and can be distributed via existing infrastructures.

- Biologically produced oils (bio-oils) can be used in diesel engines

- Straight vegetable oil (SVO)

- Waste vegetable oil (WVO)

- Biodiesel obtained from transesterification of animal fats and vegetable oil, directly usable in petroleum diesel engines

- Oils produced from various wastes

- Thermal depolymerization from waste materials can extract methane and oil similar to petroleum

- Methane and oils are being extracted from landfill wells and leachate in test sites

Gaseous Biofuels

- Bio-methane produced by the natural decay of garbage or agricultural manure can be collected for use as fuel

- It is also possible to estimate the number of animals needed for desirable size of biogas driven engine with Biogas Calculator

- Wood gas can be extracted from wood and used in petrol engines.

- Hydrogen can be produced in water electrolysis or, less ecologically, by cracking any hydrocarbon fuel in a reformer, some fermentation processes also produce hydrogen, such as A.B.E. fermentation

- Gasification, that produces carbon monoxide.

How is Bio-diesel produced from Plant Oils?

The process of converting vegetable oil into biodiesel fuel is called transesterification, and is fortunately much less complex than it sounds.

- Transesterification refers to a reaction between an ester of one alcohol and a second alcohol to form an ester of the second alcohol and an alcohol from the original ester, as that of methyl acetate and ethyl alcohol to form ethyl acetate and methyl alcohol Chemically, transesterification means taking a triglyceride molecule or a complex fatty acid, neutralizing the free fatty acids, removing the glycerin and creating an alcohol ester. This is accomplished by mixing methanol with sodium hydroxide to make sodium methoxide . This liquid is then mixed into vegetable oil. The entire mixture then settles. Glycerin is left on the bottom and methyl esters, or biodiesel, is left on top. The glycerin can be used to make soap (or any one of 1600 other products) and the methyl esters is washed and filtered.

BIODIESEL'S PHYSICAL CHARACTERISTICS

Specific Gravity	**0.87 to 0.89**
Kinematic viscosity @40°C	**3.7 to 5.8**
Cetane Number	**46 to 70**
Higher heating value (btu/lb)	**16,928 to 17,996**
Sulfur, wt%	**0.0 to 0.0024**
Cloud point °C	**-11 to 16**
Pour point °C	**-15 to 13**
Iodine number	**60 to 135**
Lower heating value (btu/lb)	**15,700 to 16,735**

Environmental Benefits

- Hydrocarbons are reduced by 95%
- Speciated hydrocarbons are reduced by 50%
- Carbon monoxide is reduced by 43%
- Particulate matter is reduced as much as 86%
- Sulfur oxides and sulfates are eliminated by using biodiesel
- Aromatic compounds (mutagenicity compounds) are reduced 75%-90%
- Carbon dioxide is reduced 78%
- Nitrogen oxide is increased by 5.8%, but the use of an additive or a catalytic converter now virtually eliminates this increase

My project work would be basically focused on the study of environmental beneficial aspect of using biodiesel as an alternative fuel.

1- Significant Characteristics of Bio-diesel
2- Biodiesel - Merits
3- Biodiesel De-Merits
4- Bio-Diesel – Other Issues

- Toxicological Studies
    - Prerequisite for new fuel
- Biodegradability
    - Adulteration

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ANJU PANWAR

(R070207003)

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Chapter -1

INTRODUCTION:

Diesel fuel is widely used throughout the transportation, construction and agricultural industries of the WORLD. An alternative that has developed is biodiesel. Biodiesel is a renewable, bio based fuel that is created from oilseed crops, vegetable oils and animal fats. It can be used in place of traditional petroleum-based diesel fuel. Biodiesel has several advantages, including reduced emissions and the fuel's biodegradable and nontoxic nature. Biodiesel is considered carbon neutral, in that it does not produce carbon dioxide. In 2007, petroleum-based diesel consumption in the United States was 64.6 billion gallons. In early 2008, the U.S. had the capacity to produce more than 2.2 billion gallons of biodiesel per year or the equivalent of just over 3 percent of total petroleum diesel consumption.

Biodiesel is an alternative fuel similar to conventional or 'fossil' diesel. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil. The process used to convert these oils to Biodiesel is called transesterification. This process is described in more detail below. The largest possible source of suitable oil comes from oil crops such as rapeseed, palm or soybean. In the UK rapeseed represents the greatest potential for biodiesel production. Most biodiesel produced at present is produced from waste vegetable oil sourced from restaurants, chip shops, industrial food producers such as Birdseye etc. Though oil straight from the agricultural industry represents the greatest potential source it is not being produced commercially simply because the raw oil is too expensive. After the cost of converting it to biodiesel has been added on it is simply too expensive to compete with fossil diesel. Waste vegetable oil can often be sourced for free or sourced already treated for a small price. (The waste oil must be treated before conversion to biodiesel to remove impurities). The result is Biodiesel produced from waste vegetable oil can compete with fossil diesel. More about the cost of biodiesel and how factors such as duty play an important role can be found here.

HISTORY:

The concept of using vegetal oil as an engine fuel likely dates when Rudolf Diesel (1858-1913) developed the first engine to run on peanut oil, as he demonstrated at the World Exhibition in Paris in 1900. Unfortunately, R. Diesel died 1913 before his vision of a vegetable oil powered engine was fully realized.

> "The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in the course of time as important as the petroleum and coal tar products of the present time" Rudolf Diesel, 1912

After R. Diesel death the petroleum industry was rapidly developing and produced a cheap by-product "diesel fuel" powering a modified "diesel-engine". Thus, clean vegetable oil was forgotten as a renewable source of power.

Modern diesels are now designed to run on a less viscous fuel than vegetable oil but, in times of fuel shortages, cars and trucks were successfully run on preheated peanut oil and animal fat. It seems that the upper rate for inclusion of rapeseed oil with diesel fuel is about 25% but crude vegetal oil as a diesel fuel extender induces poorer cold-starting performance compared with diesel fuel or biodiesel made with fatty esters (McDonnel K et al. JAOCS 1999, 76, 539). Today's diesel engines require a clean-burning, stable fuel operating under a variety of conditions. In the mid 1970s, fuel shortages spurred interest in diversifying fuel resources, and thus biodiesel as fatty esters was developed as an alternative to petroleum diesel. Later, in the 1990s, interest was rising due to the large pollution reduction benefits coming from the use of biodiesel. The use of biodiesel is affected by legislation and regulations in all countries (Knothe G, Inform 2002, 13, 900). On February 9, 2004, the Government of the Philippines directed all of its departments to incorporate one percent by volume coconut biodiesel in diesel fuel for use in government vehicles. The EU Council of Ministers adopted new pan-EU rules for the detaxation of biodiesel and biofuels on October 27, 2003. Large-volume production occurs mainly in Europe, with production there now exceeding 1.4 million tons per year. Western European biodiesel production capacity was estimated at about 2 million metric tons per year largely produced through the transesterification process, about one-half thereof in Germany (440,000 and 350,000 MT in France and Italy, respectively). In the United States, by 1995, 10 percent of all federal vehicles were to be using alternative fuels to set an example for the private automotive and fuel industries. Several studies are now funded to promote the use of blends of biodiesel and heating oil in USA. In USA soybean oil is the principal oil being utilized for biodiesel (about 80,000 tons in 2003).

WHAT IS BIODIESEL ?

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.

Biodiesel (or bio-fuel) is the name for a variety of ester-based fuels (fatty esters) generally defined as the mono alkyl esters made from vegetable oils, such as soybean oil, canola or hemp oil, or sometimes from animal fats through a simple trans-esterification process. This renewable source is as efficient as petroleum diesel in powering unmodified diesel engine.

BIODIESEL'S PHYSICAL CHARACTERISTICS

Specific Gravity	**0.87 to 0.89**
Kinematics viscosity @40°C	**3.7 to 5.8**
Cetane Number	**46 to 70**
Higher heating value (btu/lb)	**16928 to 17, 996**
Sulfur, wt%	**0.0 to 0.0024**
Cloud point °C	**-11 to 16**
Pour point °C	**-15 to 13**
Iodine number	**60 to 135**
Lower heating value (btu/lb)	**15,700 to 16,735**
Flash point	**~ 130 C**

Sources of Biodiesel:

Diesels can be run on almost any kind of oil: corn, soy, whale...but probably will end up running on a kind of algae since it is by weight 50% oil or so.

- Soybean: 40 to 50 US gal/acre (35 to 45,000 L/km)
- Rapeseed: 110 to 145 US gal/acre (100 to 130,000 L/km)
- Mustard: 140 US gal/acre (130,000 L/km)
- Jatropha: 175 US gal/acre (160,000 L/km)
- Palm oil: 650 US gal/acre (580,000 L/km) [6]
- Algae: 10,000 to 20,000 US gal/acre (9,000,000 to 18,000,000 L/km)

Economic aspects

Beneficial biomass utilization in East Asia is expected to generate extra income, through value addition, for local stakeholders including farmers, labourers, energy producers and local/national governments. It may contribute to economic gains for East Asian countries, by reducing imports of fossil fuels, and less dependence on imported fuels may also enhance energy security in the region. However, for maximising economic benefits, energy production potential of each biomass resource should be evaluated and appropriate technologies should be used for energy production. To ascertain this, some case studies have been conducted in the region, hitch performed economic impact assessment of bioenergy, in terms of value addition at each stage, such as job creation, tax revenue generation, and foreign trade.

Social aspects

Development of biofuels may have several socio-economic implications in East Asian countries. Positive social impacts of bioenergy are increased employment and income in rural areas, and hence, reduction in income disparity among rural riches and poor and in urban and rural areas; higher income may contribute to better health prospects for all, particularly, for women and children; better life style, etc. Negative impacts could be increased pressure on natural resources such as water, land and forests. Also, biofuel crops may compete with other food and fodder crops and reduce their supplies resulting in higher food prices. The case studies on social issues were aimed at preliminary estimation of disparity of income in the region and its reduction due to bioenergy development. The case studies were based upon relevant indices developed by international organizations but further investigations are needed for reliable and accurate estimations of social impacts.

Environmental aspects

Along with the interest to utilize biomass for energy production, there exists a myriad of interconnected environmental factors that has to be taken into account. The merits of any biomass energy production should be assessed along with some crucial sustainable indicators and environmental concerns including: deforestation / land use, water management, fertilizers and pesticides, carbon footprint and energy inputs. If large amounts of energy and resources are consumed during the production of biomass and biofuels, the entire system's energy balance will tend to result in energy losses instead of gains. The same logic holds for GHGs; low or zero carbon biofules can only be achievable with proper conditions in place The lifecycle carbon-footprint and energy equilibrium of such a system has to be considered carefully.

Efficiency and economic arguments

According to a study by Drs. Van Dyne and Raymer for the Tennessee Valley Authority, the average US farm consumes fuel at the rate of 82 litres per hectare (8.75 US gallons per acre) of land to produce one crop. However, average crops of rapeseed produce oil at an average rate of 1,029 L/ha (110 US gal/acre), and high-yield rapeseed fields produce about 1,356 L/ha (145 US gal/acre). The ratio of input to output in these cases is roughly 1:12.5 and 1:16.5. Photosynthesis is known to have an efficiency rate of about 3-6% of total solar radiation and if the entire mass of a crop is utilized for energy production, the overall efficiency of this chain is currently about 1%While this may compare unfavorably to solar cells combined with an electric drive train, biodiesel is less costly to deploy (solar cells cost approximately US$1,000 per square meter) and transport (electric vehicles require batteries which currently have a much lower energy density than liquid fuels).

However, these statistics by themselves are not enough to show whether such a change makes economic sense. Additional factors must be taken into account, such as: the fuel equivalent of the energy required for processing, the yield of fuel from raw oil, the return on cultivating food, the effect biodiesel will have on food prices and the relative cost of biodiesel versus petrodiesel.

The debate over the energy balance of biodiesel is ongoing. Transitioning fully to biofuels could require immense tracts of land if traditional food crops are used (although non food crops can be utilized). The problem would be especially severe for nations with large economies, since energy consumption scales with economic output. If using only traditional food plants, most such nations do not have sufficient arable land to produce biofuel for the nation's vehicles. Nations with smaller economies (hence less energy consumption) and more arable land may be in better situations, although many regions cannot afford to divert land away from food production.

For third world countries, biodiesel sources that use marginal land could make more sense. e.g. honge oil nuts grown along roads or jatropha grown along rail lines.

In tropical regions, such as Malaysia and Indonesia, oil palm is being planted at a rapid pace to supply growing biodiesel demand in Europe and other markets. It has been estimated in Germany that palm oil biodiesel has less than 1/3 the production costs of rapeseed biodiesel The direct source of the energy content of biodiesel is solar energy captured by plants during photosynthesis. Regarding the positive energy balance of biodiesel

Energy security

One of the main drivers for adoption of biodiesel is energy security. This means that a nation's dependence on oil is reduced, and substituted with use of locally available sources, such as coal, gas, or renewable sources. Thus a country can benefit from adoption of biofuels, without a reduction in greenhouse gas emissions. Whilst the total energy balance is debated, it is clear that the dependence on oil is reduced. One example is the energy used to manufacture fertilizers, which could come from a variety of sources other than petroleum. The US NREL says that energy security is the number one driving force behind the US biofuels programme. and the White House "Energy Security for the 21st Century" makes clear that energy security is a major reason for promoting biodiesel. The EU commission president, Jose Manuel Barroso, speaking at a recent EU biofuels conference, stressed that properly managed biofuels have the potential to reinforce the EU's security of supply through diversification of energy sources

Environmental effects

The surge of interest in biodiesels has highlighted a number of environmental effects associated with its use. These potentially include reductions in greenhouse gas emissions deforestation, pollution and the rate of biodegradation.

Food, Land and Water vs Fuel

In some poor countries the rising price of vegetable oil is causing problems. Some propose that fuel only be made from non-edible vegetable oils like camelina, jatropha or seashore mallowwhich can thrive on marginal agricultural land where many trees and crops will not grow, or would produce only low yields.

Others argue that the problem is more fundamental. Farmers may switch from producing food crops to producing biofuel crops to make more money, even if the new crops are not edible. The law of supply and demand predicts that if fewer farmers are producing food the price of food will rise. It may take some time, as farmers can take some time to change which things they are growing, but increasing demand for first generation biofuels is likely to result in price increases for many kinds of food. Some have pointed out that there are poor farmers and poor countries who are making more money because of the higher price of vegetable oilBiodiesel from sea algae would not necessarily displace terrestrial land currently used for food production and new algaculture jobs could be created.

Chapter-2

Executive Summary.

Approximately 24% of total energy consumption in India contributed 14% of net greenhouse gas emissions, the highest emitting sector after stationary energy. Over three-quarters of this energy consumption, and the associated emissions, is attributed to road transport In India fuel consumption for road transport is increasing by 3-4% per year, with diesel usage increasing at more than twice the rate of petrol By 2010, greenhouse gas emissions from the transport sector are predicted to be 44% higher than they were in 1990 The significant, and steadily rising contribution of fossil fuels to global emissions of greenhouse gases is one of two primary drivers for the increasing focus on alternative transport fuels such as biodiesel. The other is the increasing threat of worldwide fossil fuel scarcity and the implications of this for economic and national security. Biodiesel is a renewable fuel whose primary feedstock's, such as used cooking oil, tallow and vegetable oils, can be grown and/or sourced locally for use in short turn-around times. Unlike fossil-based fuel, biodiesel is also part of a closed carbon loop in which the tailpipe

Emissions of carbon from biodiesel are, theoretically, no more than was extracted from the atmosphere by the feedstock plants during their growth. While biofuels (including ethanol) currently account for less than 1% of the overall fuel market in Australia, biodiesel production grew fourfold in one year from

2003/04 to 2004/05 and the indications are that this growth trend will continue In Australia, local government leads the way with biodiesel uptake. Beginning in 2002, biodiesel is now used by over 20 local governments and at least five of these operate their entire depot fleet on biodiesel blends. Local governments reported overwhelmingly positive outcomes from their uptake of biodiesel. There are no operational problems reported from the use of certified fuel in conventional diesel engines, and over 80% of experienced councils indicated that biodiesel will continue to play a major role in council's future fuel

Usage. To build on learning's from these experienced councils and ensure that the future implementation of biodiesel in local governments is both appropriate and environmentally sustainable, this report provides useful tools (project checklist, guidance on how to calculate GHG abatement and a summary reference list of benefits and issues) to assist councils with the planning and implementation of a successful biodiesel project, best practice examples for biodiesel uptake in the form of council testimonials and detailed case studies from five local governments, an example tender document to guide councils in the development of their own tender criteria, and also details of 26 council biodiesel projects covering five states. Council motivations for biodiesel uptake, in order of significance, are

- Reduced greenhouse gas emissions;
- Contributing to council abatement goals;
- Reduced environmental pollution;
- Fuel security (in terms of reduced reliance on
- fossil fuels);
- Improved community health;

- Encouraging local economic development;

- Financial savings;

Opportunity to demonstrate leadership. Studies show that biodiesel uptake can lead to life-cycle reductions in greenhouse gas emissions of up to 90% dependant on the blend. In addition to greenhouse gases, diesel vehicles contribute a disproportionate amount of other emissions such as oxides of nitrogen and particulate matter, contributing to the formation of urban ozone and photochemical smog, and increasing cardiovascular, respiratory and cancer-related morbidity and mortality. All biodiesel blends result in significant reductions in particulate matter of between 30-90%, delivering clear benefits in terms of air quality and community health Councils reported many operational benefits of biodiesel uptake including improved lubricity, smoother vehicle operation, increased combustion, improved auto-ignition and safer handling. They also observed no perceptible difference in power or engine torque and noted that
Biodiesel uptake required no engine modification. The operational and environmental benefits of biodiesel
Suggest that it can be a viable and preferable alternative to diesel. However, there are broader issues for local governments to consider. These include fuel quality, sustainability of supply, environmental and social impacts of feedstock's, cost, tax laws and warranty regulations. Many types of council indicated concern regarding feedstock sin terms of their sustainability, the life-cycle environmental impacts of their production, extraction and transportation, and the social and economic impact of food resources being used for fuel purposes. A majority area of concern regarding sustainable feedstocks is the use of imported palm oil and the impact that an unregulated market is already having on deforestation, biodiversity and societies in tropical regions. Councils indicated a preference for biodiesel from domestic, locally sourced and non-GMO (Genetically Modified Organism) products. Most councils report that biodiesel uptake is generally cost-neutral. However, there are further potential economic benefits of biodiesel uptake relating to local economic development, and local governments can play an instrumental role in maximising these benefits through effective research and planning. Local governments are thinking ahead and want to position themselves within an appropriate and stable framework that allows them to make sound environmental, economic and social decisions regarding council's future fuel use. Given the relatively early stage of the Australian biodiesel industry, this presents opportunities to review current policies and strategies surrounding biofuels to alleviate local government concerns. Within this context, the primary opportunity for local governments in relation to biodiesel exists in their being able to influence the direction that the industry takes from this point onwards.
:

- Certification system around sustainable feedstock's
- and sources;

- Reliable emissions data;

- Rebates and incentives;

- Planning policies to support renewable industries;

- Cost guarantees;
- Assurance of supply and standards;
- Improved supply structure;
- Clarity and support on warranties - both producers' and manufacturers

More research, information and education. With the announcement in June 2007 of a Victorian Parliamentary Inquiry into mandatory ethanol and biofuels targets in Victoria, set within the context of the existing Victorian Biofuels Action Plan, the Victorian State Government is well positioned to adopt a leadership role in Australia through establishing a sustainable model for biodiesel uptake and development that can be replicated in other states. To ensure that this model meets the needs of local governments and safeguards against any potentially adverse environmental and social implications of
Biodiesel, it is recommended that the Victorian Government continue to liaise with ICLEI Oceania and other stakeholders in the local government sector. The Victorian Government can play a key role through support for initiatives designed to further expand the body of knowledge and understanding around biodiesel, and provide education and assistance for potential users, including promoting the outcomes of this report. Overall, this research shows that biodiesel could, within strict guidelines, offer a more environmentally acceptable and domestically secure interim fuel option that at least contributes fewer greenhouse gases and improves air quality, until such time as more advanced and ideally carbon-neutral transport technologies become commercially viable. However, in order to have more than a limited impact on reducing the environmental impact of the transport sector and reducing reliance on fossil fuels, the uptake of less environmentally harmful alternative fuels needs to be part of a fully integrated and aligned transport approach. Councils therefore recognize that efforts to increase biodiesel uptake need to be pursued in conjunction with increasing fuel efficiency and reducing overall travel demand.

Chapter-3

Trends, Outlook, & Opportunities

In the USA, the market for biodiesel is growing at an alarming rate - from 25 million gallons per year in 2004 to 450+ million gallons in 2007. The total biodiesel being sold in the U.S. amounts to less than 1% of all diesel consumption. In Europe, biodiesel represents 2-3% of total transportation consumption and is targeted to reach 6% by 2010. In China, India, Brazil and Europe, economic and environmental security concerns are giving birth to new government targets and incentives, aimed at reducing petroleum imports and increasing the consumption and production of renewable fuels. Europe, Brazil, China and India each have targets to replace 5% to 20% of total diesel with biodiesel. For this market study, Emerging Markets Online examines the trend towards lower cost multiple feedstock options, and provides details on new feedstock's and global trade trends.

This study provides details of the leading jatropha curcas projects in India, Africa, Asia, and Latin America. This study also reviews major projects in progress for lower-cost feedstocks from renewable diesel, tallow, yellow grease, and waste recycling. Algae based biodiesel projects are also reviewed, along with technologies for renewable diesel via pyrolysis, biomass waste to liquids via GTL, Fischer-Tropsch gas to liquids and others. This study tracks the global markets for biodiesel growth, and provides 5 to 10 year forecasts for biodiesel demand, consumption and production. Europe, the U.S., Brazil, China, and India are each covered as market studies. Proprietary forecasts developed for this study are also used to produce 2020 "Scenarios" for Europe, the U.S., Brazil, China, and India. Biodiesel *2020* also provides an outlook and scenarios for the transition from first generation to second generation biodiesel projects in developed countries and in the emerging markets.

The initial results from the study Biodiesel 2020: A Global Market Survey find that new developers, farmers, feedstock providers, producers, and investors who can meet growing demands for supply are expected to benefit from this emerging market.

In addition, this study finds key advantages in the future will be available to producers and investors to supply future needs with new and improved technologies; alternative feed stocks with higher yields such as jatropha and algae biodiesel; production scalability and flexibility options; supply chain, distribution and co-location strategies; innovative risk management strategies; and industry-friendly government targets and tax incentives committed to promoting the awareness and growth of the industry.

With an eye on the future, Biodiesel 2020: A Global Market Survey provides forecasts and scenarios to the year 2020 for the U.S. and European markets as well as the "big emerging markets" of China, Brazil and India. For Brazil, China and India, the study includes long-term forecasts and year 2020 scenarios, each measuring growth in the diesel and biodiesel markets, as well as focusing on the potential for biodiesel growth.

Chapter-4

METHODLOGY

Biodiesel production -the biofuel, biodiesel, through either transesterification or alcoholysis. The process involves reacting vegetable oils or animal fats catalytically with a short-chain

Transesterification chemistry

A reaction scheme for transesterification is as follows:

R_1, R_2, and R_3 in this diagram represent long carbon chains that are too lengthy to include in the diagram. Animal and plant fats and oils are typically made of triglycerides which are esters of free fatty acids with the trihydric alcohol, glycerol. In the transesterification process, the alcohol is deprotonated with a base to make it a stronger nucleophile. Commonly, ethanol or methanol are used. As can be seen, the reaction has no other inputs than the triglyceride and the alcohol.

Steps in the process

The major steps required to synthesize biodiesel are as follows:

Purification

If waste vegetable oil (WVO) is used, it is filtered to remove dirt, charred food, and other non-oil material often found. Water is removed because its presence causes the triglycerides to hydrolyze to give salts of the fatty acids instead of undergoing transesterification to give biodiesel. At home, this is often accomplished by heating the filtered oil to approximately 120 °C. At this point, dissolved or suspended water will boil off. When the water boils, it spatters (chemists refer to it as "bumping"). To prevent injury, this operation should be done in a sufficiently large container (at most two thirds full) which is closed but not sealed.

Neutralization of free fatty acids

A sample of the cleaned oil is titrated against a standard solution of base in order to determine the concentration of free fatty acids (RCOOH) present in the waste vegetable oil sample. The quantity (in moles) of base required to neutralize the acid is then calculated.

Transesterification

While adding the base, a slight excess is factored in to provide the catalyst for the transesterification. The calculated quantity of base (usually sodium hydroxide) is added slowly to the alcohol and it is stirred until it dissolves. Sufficient alcohol is added to make up three full equivalents of the triglyceride, and an excess of usually six parts alcohol to one part triglyceride is added to drive the reaction to completion. The solution of sodium hydroxide in the alcohol is then added to a warm solution of the waste oil, and the mixture is heated (typically 50 °C) for several hours (4 to 8 typically) to allow the transesterification to proceed. A condenser may be used to prevent the evaporative losses of the alcohol. Care must be taken not to create a closed system which can explode.

Advantages from transesterification

- Bio-diesel is non toxic and biodegradable
- It reduces the emission of harmful pollutants from diesel engine (80% less CO2 and 100% less sulpher dioxide)
- It has a high cetane number than diesel. Cetane number is a measure of fuels ignition quality. The high cetane number of bio-diesel contributes to easy cold starting and low idle noise.
- It increases the life of diesel engine as it is more lubricating
- Bio-diesel replaces the exhaust order of engine with a more pleasant smell.

Final process

The lower layer of the process is composed primarily of glycerine and other waste products. The top layer, a mixture of biodiesel and alcohol, is decanted. The excess alcohol can be distilled off, or it can be extracted with water. If the latter, the biodiesel should be dried by distillation or with a drying agent.

Reaction

An example of the transesterification reaction equation, shown in skeletal formulas:

Since natural oils are typically used in this process, the alkyl groups of the triglyceride are not necessarily the same. Therefore, distinguishing these different alkyl groups, we have a more accurate depiction of the reaction:

R_1, R_2, R_3 : Alkyl group.

During the esterification process, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkali (NaOH, KOH, or Alkoxides). The main reason for doing a titration to produce biodiesel, is to find out how much alkaline is needed to completely neutralize any free fatty acids present, thus ensuring a complete transesterification. Empirically 6.25 g / L NaOH produces a very usable fuel. One uses about 6 g NaOH when the WVO is light in colour and about 7 g NaOH when it is dark in colour.

The alcohol reacts with the fatty acids to form the mono-alkyl ester (or biodiesel) and crude glycerol. The reaction between the biolipid (fat or oil) and the alcohol is a reversible reaction so the alcohol must be added in excess to drive the reaction towards the right and ensure complete conversion.

Base catalyzed mechanism

The transesterification reaction is base catalyzed. Any strong base capable of deprotonating the alcohol will do (e.g. NaOH, KOH, Sodium methoxide, etc.). Commonly the base (KOH, NaOH) is dissolved in the alcohol to make a convenient method of dispersing the otherwise solid catalyst into the oil. The ROH needs to be very dry. Any water in the process promotes the saponification reaction, thereby producing salts of fatty acids (soaps) and consuming the base, and thus inhibits the transesterification reaction. Once the alcohol mixture is made, it is added to the triglyceride. The reaction that follows replaces the alkyl group on the triglyceride in a series of steps.

The carbon on the ester of the triglyceride has a slight positive charge, and the carbonyl oxygens have a slight negative charge. This polarization of the C=O bond is what attracts the RO^- to the reaction site.

```
                                  R1
    Polarized attraction |
RO-   ------------------->  C=O
                                  |
                                  O-CH2-CH-CH2-O-C=O
                                              |          |
                                            O-C=O      R3
                                               |
                                              R2
```

This yields a tetrahedral intermediate that has a negative charge on the former carbonyl oxygen:

```
   R1
   |
RO-C-O- (pair of electrons)
   |
   O-CH2-CH-CH2-O-C=O
         |      |
         O-C=O  R3
```

```
      |
      R2
```

These electrons then fall back to the carbon and push off the diacylglycerol forming the ester.

```
  R1
  |
RO-C=O

+
  -O-CH2-CH-CH2-O-C=O
         |       |
         O-C=O   R3
           |
           R2
```

Then two more RO groups react via this mechanism at the other two C=O groups. This type of reaction has several limiting factors. RO^- has to fit in the space where there is a slight positive charge on the C=O. MeO- works well because it is small in size. As the chain length of the RO- group increases, reaction rates decrease. This effect is called steric hindrance. This effect is a primary reason the short chain alcohols, methanol and ethanol, are typically used.

There are several competing reactions, so care must be taken to ensure the desired reaction pathway occurs. Most methods do this by using an excess of RO^-.

The acid-catalyzed method is a slight variant that is also affected by steric hindrance.

Quality control-

- The key quality control issues involve complete (or nearly complete) removal of alcohol, catalyst, water, soap, glycerin and un-reacted or partially reacted triglycerides. Failing to remove these causes bio-diesel to fail in one or more fuel standards.
- The presence free fatty acids (FFA) interfere in transesterification, deactivating the basic catalysts.

Quality assurance

- Bio-diesel is recognized world wide as an alternative fuel and qualities for mandatory programmers in both the European Union and USA. Of the many required tests producers use the test method EN 14105 and or ASTM D6584 as the most critical "Pass/fail" tests of bio-diesel. These critical tests are often the first run. If the fuel does not pass, re-work or blending is done before further testing.

ASTM D6585 method:-

- Presence of glycerin in fuel can cause clogged fuel system, injector deposits, filter plugging and built up in the vehicles fuel tanks. Therefore low level of free and total glycerin is critical to specification of bio-diesel.
- High levels of free and total glycerin are caused by improper or low conversion of oil or fat into the desired mono-methyl-esters. The bio diesel assay for free and total glycerin is outlined in ASTM D6584 (American Society for Testing and Material), which provides method for quantitative determination of free and total glycerin in 100% bio diesel fuel(B100% methyl ester) by high temperature gas chromatography after silylating the sample with N-methyl-N-(trimethylsilyl) trifluoroacetamide (MSTFA). An example of the GC analysis of bio-diesel following ASTM D6584 methodology is as ;

Product Quality and Registration.

Prior to use as a commercial fuel, the finished biodiesel must be analyzed using sophisticated analytical equipment to ensure it meets ASTM specifications. Additionally, all biodiesel produced must be registered with the Unites States Environmental Protection Agency under 40 CFR Part 79. The most important aspects of biodiesel production to ensure trouble free operation in diesel engines are:

* Complete Reaction
* Removal of Glycerin
* Removal of Catalyst
* Removal of Alcohol
* Absence of Free Fatty Acids

These parameters are all specified through the biodiesel standard, ASTM D 6751. For a complete copy of ASTM D 6751 contact ASTM at www.astm.org. This standard identifies the parameters the pure biodiesel (B100) must meet before being used as a pure fuel or being blended with petrodiesel. The National Biodiesel Board has adopted ASTM biodiesel specifications. The specification is listed on the following page. The NBB has also formed the National Biodiesel Accreditation Commission that has put into place an accreditation program for companies selling biodiesel and biodiesel blends. It is a Good Housekeeping™ type seal of approval for biodiesel marketers, and provides the consuming public with additional assurances and confidence that biodiesel purchased form a Certified Biodiesel Marketer will meet ASTM specifications. Certifications are pending, and will be posted on the NBB web site at www.biodiesel.org. Once the program has been fully implemented, NBB recommends that all biodiesel marketers become certified, and that all biodiesel consumers specify the purchase of biodiesel from NBAC Certified Marketers.

Problems with Current Production Process:

Biodiesel is most commonly produced through the transesterification of fatty acids in the presence of a homogeneous catalyst and methanol. There are problems associated with this process.

- Glycerin, a valuable by-product, is produced & must be separated.
- Excess free fatty acids require more catalyst and can cause catalyst poiling.
- Raw oils with low fatty acid content are expensive.
- The presence of water reduces catalyst efficiency.
- Batch reactors do not optimize production time.
- Excess methanol is costly and environmentally harmful.

MOTIVATION FACTORS FOR BIODIESEL

- Biodiesel is non-toxic, biodegradable and exhibits high flash point-handling and storage are therefore safer than petroleum diesel.
- Biodiesel can be used in existing engines and fuel injection equipment without negative impact to operating performance. Virtually the same MPG rating as conventional diesel.
- Biodiesel can extend engine life because of its superior lubricating properties. Can be used as lubricity improver additive in petro diesel.
- It operates well in a conventional diesel engine with very few or no engine modifications.
- It can be used neat and as blend with conventional diesel
- Biodiesel reduces tailpipe emissions, visible smoke and noxious odors.

LUBRICITY BENEFITS

Percent Biodiesel	Number 2	Number 1
0.0	536	671
0.4	481	649
1.0	321	500
2.0	322	355
20.0	314	318
100.0	314	314

Number 1 &2 diesel (500 ppm max. sulfur)

For No. 2 diesel 1% biodiesel was sufficient. For No. 1 diesel 2% biodiesel was sufficient. For still low sulfur diesel bodiesel dozes can be increased to meet lubricity requirement. Development of an additive which improves the lubricity and stability of both diesel and biodiesel. Dozes levels of 50-150 ppm are sufficient to meet lubricity requirements.

ECONOMIC FACTORS

- Biodiesel is 1.5-2 times costlier than petro-diesel, depending upon the price of feed vegetable oil. Cost of vegetable oil accounts for about 75% cost of biodiesel.
    - Biodiesel and biodiesel blends have not penetrated the market due to its higher cost.
    - To have a greater impact on the Indian Farm/Rural sector biodiesel may have to compete with petro-diesel.
    - Use of alternative low cost vegetable oils/feedstock may reduce the cost of biodiesel.
    - One possible solution to this problem is to market biodiesel as a fuel additive that would be blended in the range of 1-3% by volume with petro-diesel to enhance fuel performance with respect to lubricity, cetane no., emissions and biodegradability
    - Biodiesel may be more competitive as diesel fuel additive.

LIMITATION OF VEGETABLE OILS AS DIESEL FUEL

- High viscosity
- Poor atomization
- Poor volatility
- Thermal cracking in diesel engines.
- Poor oxidation stability.
- Polymerization in combustion chamber leading to deposits.
- Injection fouling by deposits
- Fuel line and filter clogging
- Polymerization of triglycerides in the lube oil

Hence modification of vegetable oils is necessary for efficient & trouble free engine operation.

TRANSESTERIFICATION OF VEGETABLE OIL

Vegetable Oil + (Triglyceride)	Methanol / ethanol	-	Esters +	Glycerin
CH2 – OCOR				CH2OH
CH – OCOR +	3CH3OH	-	3RCOOCH3 +	CH2OH
CH2 – OCOR				CH2OH

'R' REPRESENTS HYDROCARBON CHAINS

OTHER REACTIONS

Fatty Acids RCOOH	Methanol + CH3OH	-	Ester RCOOCH3 +	Water H2O

COMMERCIAL BIODIESEL TECHNOLOGIES

- Base catalyzed transesterification with refined oils.
- Base catalyzed transesterification with low fatty acid greases and fats.
- Acid esterification followed by transesterification of low or high free fatty acid fats and oils.

Others under development include:

- Biocatalysed transesterification.
- Pyrolysis of vegetable oils/seed.

Transesterification is simple and easily adaptable at commercial scale.

PROBLEMS OF BIODIESEL PRODUCTION

- Free fatty acids interfere with transesterification deactivate the basic catalysts – loss of catalyst and biodiesel yield.
- Water deactivates both basic and acidic catalysts. Drying of oil may be required.
- Soaps formed with basic catalyst form emulsion and foam and difficult to remove.
- When processing feedstock's with high free fatty acids additional steps must be taken.
- After basic transesterification, the purification and adequate testing during processing is required to produce fuel grade esters.

Chapter -5

Biodiesel from Jatropha

There are many plant species such as *Jatropha curcas* (Ratan Jyot), *Pongamia pinnata* (Karanja), *Mesua ferrea* (Nahar) etc. which bear seeds rich in oil. Around 450 such species are found in our country, but Jatropha and Karanja and Nahar are the three species which are abundantly found in NE region of India. North eastern part of India has a great potential of producing biodiesel from these species. Utilization of biodiesel in diesel engine and farm machinery has enormous potential for rural development in terms of employment opportunity for youth and infrastructure development in NE region. The by-product of the oil extraction from seeds and biodiesel production process could also be utilized for organic fertilizer, biogas production and for soap making.

In India, biodiesel production from variety of non edible oils have been pursued by many organization and the demonstration phase of national mission on bio-diesel has already been launched on April 28, 2006 by Ministry of Rural Development at New Delhi. During this phase the promotion of Jatropha cultivation and setting up demonstration oil extraction and transesterification facilities shall be taken up along with dissemination of information.

The biodiesel has many positive attributes and they are being summarized as:

i. It is plant-derived, not petroleum-derived, and as such its combustion eliminates life cycle carbon-dioxide emissions, a "greenhouse" gas since carbon dioxide emitted during combustion is recycled in the photosynthesis process occurring in the plants used as raw materials for biodiesel production.

ii. It can be domestically produced, offering the possibility of reducing petroleum imports.

iii. The higher Cetane number of biodiesel compared to fossil diesel indicates the potential for higher engine performance.

iv. It is biodegradable

v. Relative to conventional diesel fuel, biodiesel reduces emission of particulate matter by 40%, unburned hydrocarbons by 68%, carbon monoxide by 44%, sulphates by 100%, PAHs (polycyclic aromatic hydrocarbons) by 80%, and carcinogenic nitrated PAHs by 90%, on average. The use of biodiesel complements the working of the catalyst or and can help a current Euro-I vehicles attain the Euro-III standards, thus significantly reducing the environmental pollution.

vi. The superior lubricating property of biodiesel increases the engine efficiency.

vii. The higher flash point of biodiesel makes it safe to store.

viii. The biodiesel molecules are simple hydrocarbon chains, containing no sulphur which is concern in crude oil derived petroleum products.

ix. Biodiesel contains higher amount of oxygen (up to 10%), which ensures complete combustion of hydrocarbons.

x. Use of biodiesel will lead to increased energy independence as well as increased economic activity from fuel production and utilization.

xi. Generation of new employment opportunities in cultivation, processing and production of biodiesel.

xii. Addition to the renewable energy options for decentralized distributed generation (DDG) of electricity and for motive power applications (water pumping, milling, etc.) in energy deficient rural India

xiii. Greening of wastelands and regeneration of degraded forest-lands, thereby helping in eco restoration and preventing further land degradation

xiv. Empowerment of village community through enhanced livelihood opportunities

Relevance to NE priorities

1. The NE states have very few industries causing major unemployment. Such a project shall help in creating a hub for biodiesel entrepreneurship in this region.

2. The large scale availability of unutilized non edible oil seeds in wild will set a good beginning.

3. Most of the states have encouraged large scale cultivation of Jatropha and Pongamia as cash crops.

4. Land degradation due to petroleum exploration and refining has taken place in this region. Land degradation through shifting cultivation (Jhumming) in hill districts is unavoidable process. Such a project shall promote TBO cultivation on this type pf degraded land.

5. Large numbers of villages are not electrified specially in Brahamputra basin nd in remote hilly areas. The biodiesel based decentralized power sources shall set an example of rural electrification and energy security.

Centre for Jatropha Promotion & Biodiesel (CJP) is the Global authoritative Agency for scientific commercialization of Jatropha fuel crop and designs and implements the growing of Jatropha curcas crops worldwide in a structured Agri-Supply chain, Value additions of Jatropha seeds and research activities thereon & provides support/services from "Soil to Oil" for development and establishment of the non -food Bio-fuel crops. The CJP has focused on the development of Jatropha curcas and other non-food biodiesel crops. Our primary goal is to discover and develop high-yielding crops that generate the most bio-energy per hectare of land. We have identified and developed new elite varieties of feedstock crops optimized for production under different agro-climatic conditions, economic and social parameters. We would like to introduce you to JATROPHA and our related activities. We know that energy is a matter of national security as the volatile

Middle East affects the world supply with most developing countries struggling with heavy oil import costs. The price of Crude Fossil oil is touching 100 US $ per barrel and expected to touch 150 mark within two years. As such for many countries, the question of trying to achieve greater energy independence one day through the development of biofuels has become one of 'when' rather than 'if,' and, now on a near daily basis, a biofuels programme is being launched somewhere in the developing world.

Global production of biofuels is growing steadily and will continue to do so. The global biodiesel market is estimated to reach 37 billion gallons by 2016 growing at an average annual rate of 42 percent. The rapid development of the global biodiesel industry has been closely observed by countries interested in stimulating economic growth, improving the environment and reducing dependency on imported oil. Developing Biofuels represents the most immediate and available response to at least five key challenges and opportunities:

- Coping with record-high crude-oil prices;
- The need for oil-importing countries to reduce their dependence on a limited number of exporting nations by diversifying their energy sources and suppliers;
- The chance for emerging economies in tropical regions to supply the global energy market with competitively priced liquid biofuels;
- Meeting growing energy demand in developing countries, in particular to support development in rural areas;
- And the commitments taken to reduce carbon-dioxide emissions as part of the battle against climate change

Biofuels offers new growth opportunities in many rural areas of developing countries, but it's important to guarantee the livelihoods and well-being of the most vulnerable. We must ensure that the price of food does not impair the food security of the poor.

Sustainability

Jatropha is a valuable multi-purpose crop to alleviate soil degradation, desertification and deforestation, which can be used for bio-energy to replace petro-diesel, for soap production and climatic protection, and hence deserves specific attention

Jatropha can help to increase rural incomes, self-sustainability and alleviate poverty for women, elderly, children and men, tribal communities, small farmers. It can as well help to increase income from plantations and agro-industries.

There are various trees that are suitable for bio-diesel production. Out of all these trees, Jatropha must be regarded as a sure inclusion and the foundation around which a plan can be built if for nothing but its pure hardiness and stress handling ability. It is just a tree that has enough credentials. That is why the Planning Commission of India has nominated it as ideal plant for biodiesel.

KYOTO **Carbon Savings**

Biodiesel produced from jatropha is one of the most promising solutions for tackling the growing carbon emissions from transport.

Food versus Fuel

Rushing to turn food crops — maize, wheat, sugar, palm oil — into fuel for cars, without first examining the impact on global hunger, would be a recipe for disaster. Among the potential impacts identified are increasing food prices, increasing competition over land and forests, forced evictions, impacts on employment and conditions of work, and increasing prices and scarcity of water. That is why Jatropha was recently recommended as a biofuels crop for developing countries by UN Special Rapporteur on the right to food

Breaking the cycle of poverty

onsider that 54 countries are poorer today than they were 15 years ago. And that almost half of the world's people – the vast majority of them working people – live on less than two dollars per day. We have a responsibility to make renewable energy available and affordable to all…to ensure that the poorest countries in the world are not forced to choose between feeding their people and fueling their economies.

For example, crop yields in sub-Saharan Africa are projected to fall by 20 percent under global warming;

As yields fall and demand rises, Africa will become more dependent on expensive food imports. Already the poor in sub-Saharan Africa spend 60 to 80 percent of their total income on food – that compares to approximately 10 percent in the U.S.;

Climate change induced famine may displace more than 250 million people worldwide by 2050
Consider that oil priced at >$90 per barrel has had a disproportionate impact on the poorest countries, 38 of which are net importers and 25 of which import all of their oil;

Developing countries consume roughly twice as much oil per dollar of GDP as the United States
All the while, the high cost and Inaccessibility of fossil fuels, leaves approximately 2 billion people worldwide without reliable energy sources, without refrigeration, basic communication, heat, or even light.

For developing countries, then, climate change and world's energy policies are a source of oppression, a source of sickness and a source of human suffering.

Since the two-thirds of the people in the developing world who derive their incomes from agriculture and Jatropha based biodiesel has enormous potential to change their situation for the better and poverty can be broken by Jatropha Cultivation as this dedicated crop has a huge potential for replication world -wide, improving the livelihood of many more.

At the community level, farmers that produce dedicated energy crops can grow their incomes and grow their own supply of affordable and reliable energy

At the national level, producing more biofuels will generate new industries, new technologies, new jobs and new markets. At the same time, producing more biofuels will reduce energy expenditures and allow developing countries to put more of their resources into health, education and other services for their neediest citizens

Can diesel be "cultivated"?

India & other developing countries have the potential to be a leading world producer of diesel, but the rural farmers still need to get comfortable with the idea that diesel fuel can be "harvested," but they understand one thing very clearly that they can use Jatropha plants as a source of extra earnings .
Farmers need to know that there is going to be a good market for what they produce. We are very keen to build that confidence and promote Jatropha cultivation by assisting planting, buying the seeds for refining and providing the refining technology to enable growers to make their own biodiesel.

An integrated Jatropha Biodiesel Project has three stages:

1. The first stage of the production process of bio-diesel from the seeds of Jatropha is the plantation stage.
2. Extraction stage of bio-diesel production
3. The final stage of bio-diesel production is the transesterification stage in which raw oil is transesterified to bio-diesel.

The combination of three stages of bio-diesel production and the role of each player in these stages have to be objectively defined as they can affect the economics of bio-diesel production
Therefore, we have carried out Economic analysis considering all above three stages as separate entities.

The Biodiesel industry is still young and relatively small, so as it grows to a larger scale and when an infrastructure is developed, the costs of producing and marketing biodiesel may decline. New cost-saving technologies will likely be developed to help producers use energy more efficiently, increase conversion yields and convert cheaper feedstock's into high-quality biodiesel. However, in the longer term, the biggest challenge may be the ability of the feedstock supply to keep up with growing demand. The supply of soybeans, rapeseeds and other feedstock's available for biodiesel production will be limited by competition from other uses and land constraints.

As such the key to the future of Biodiesel is finding inexpensive feed stocks that can be grown by farmers on marginal agricultural land, and Jatropha is one of many plants that hold a great deal of promise. Jatropha proves to be a promising Bio Fuel plantation and could emerge as a major alternative to Diesel thus reducing our dependence on Oil imports and saving the precious Foreign Exchange besides providing the much needed Energy Security. Jatropha oil displacing conventional fossil fuel makes the project fully eligible as a CDM project, i.e. recipient of CO2 credits.

Jatropha stacks up nicely compared with other feedstock's, as soybeans and rapeseed have a relatively low oil yield compared with Jatropha — 375 kilograms per hectare for soybeans in the United States (280 gallons per acre) and 1,000 kilograms per hectare of rapeseed in Europe (740 gallons per acre) to 3,000 kilograms per hectare of Jatropha (2,226 gallons per acre) in India. Good planning, quality planting material, standardized agronomy practices and good crop management could increase yields

Cost benefits scenario

Cost benefits scenario will depend on various factors such as seed yield, area of Production, its gestation period, and raw oil yield during various stages of bio-diesel production-plantation, extraction, and transesterification.

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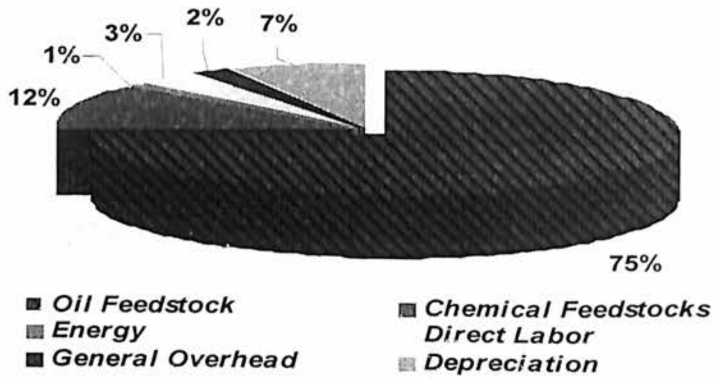
ECONOMICS of BIODIESEL



JATROPHA BUSINESS PROPOSITION

Global energy demand leads to massive opportunity for biofuels production .There is, globally, massive demand for new sources of oil driven by ever-increasing demands for energy. At the same time, the reserves of fossil fuels are declining which is leading to ever-increasing prices and concerns over security of supply. These circumstances have made the production of oil and energy from crops not only financially viable, but strategically important. As such there are a number of reasons having a strong biofuels market and hence for developing a biofuels business, not least the environmental and socio-developmental reasons, but the biofuels business stands on its own from an economic perspective.

Bio fuel, "Diesel" from Jatropha has the ability to lift many people from poverty to financial independence, from despair to respect and unemployment to business owners.

CJP is set to become one of the world's major promoters and producer of Jatropha focusing on producing Bio- oil and Biodiesel from Jatropha plant oils and believes there are globally important opportunities to be exploited….

We shall explain that what is the opportunity and how we should intend to capitalize on it, whilst providing sustainable development in the areas within which we work.

In this way

- Farmers would earn from jatropha farming
- Farm worker would have employmen
- Small rural enterprises would sell or purchase the seeds

- Small scale industries grow for oil production
- Diesel fuel production would further provide business opportunity
- By products like press-cake would be traded by villagers Energy employment and earnings would go together

The Cost

- The cost of cultivation depends upon labor availability and comes around US $ 550 per hectare
- The cost maintenance of plantation is around US $ 100-120 per year per hectare
- The cost of oil extraction roughly comes about US $ 0,12 / kg
- The cost of Bio Diesel is largely dependent on the choice of feedstock and the size of the production facility.
- The goal of SRIPHL, if Jatropha feedstock is used, the fuel will cost depending on the country approximately US $ 0, 40 per liter plus tax when applicable.

Other organizations working in this area

The following organizations are actively working in R&D Work related to biodiesel and technology demonstration.

- **Punjab Agriculture University** is actively involved in R&D work on plant oils and their esters (Biodiesel) as alternate fuel for diesel engines.
- **Indian Institute of Petroleum** is actively pursuing the utilization of non-edible oils for the production of biodiesel, additives for lubrication oils saturated and unsaturated alcohols and fatty acids and many other value added products.
- **IICT, Hyderabad.** IICT is working on the development of a green process for biodiesel using solid catalysts and enzymes.
- **Chattisgarh Biofuel Board** is actively engaged in Jatropha cultivation and biodiesel technology demonstration programs.
- **Uttranchal Biofuel Board** is working in large scale cultivation of Jatropha nd other oil bearing plants and setting up a biodiesel plant/=.
- **IIT Delhi** has conducted studies on the utilization of biodiesel of non-edible oils such as Karanja, Jatropha, Neem, Mahua & Linseed and has set up a biodiesel production facility of 100litres per batch. They are also executing a biodiesel demonstration project in the state of Orissa.

- **IOCL R&D Centre** has conducted field trial on many vehicles with different percentage of biodiesel. Transesterification process has been optimized and patented by R&D Centre of IOCL. Technology know-how has been transferred to *M/s. Venus Ethoxyethers, Goa* for commercialization.

- **The Department of Bio-energy, Tamil Nadu Agricultural University (TNAU)** has studied various parameters to optimize the process conditions for maximum biodiesel yield for alkali-catalyzed transesterification of Jatropha oil in 20 liter biodiesel reactor.

- **CSMCRI** has developed a simplified process for biodiesel production from the oil complying with Euro-3 specifications for free fatty acid methyl ester. The biodiesel developed by CSMCRI has been evaluated at Daimler Chrysler AG and found to be matching all specifications.

- Field trial of biodiesel has been done by **Tata Motors Ltd., Mahindra and Mahindra Ltd., Wartsila India ltd. etc.**

- Trains have successfully been run by **Indian Railway** on 5-10% blends of biodiesel in association with IOCL.

- **HPCL** is carrying out field trials in association with BEST, Mumbai.

- **Daimler Chrysler India** completed first phase of the field trials on two C-Class Mercedes-Benz cars powered by pure biodiesel and clocked over 5900 Km under hot and humid conditions.

- **NOVOD** has initiated test run by blending 10% of biodiesel in collaboration with IIT-Delhi in Tata Sumo and Swaraj Mazda vehicles.

- **Haryana State Transport** buses have been run by using biodiesel in association with IOCL.

- **Garware Chemicals** has started commercial production in its 100 tpd plant at Aurangabad.

- **Southern Online** has started commercial biodiesel production in its 30tpd plant at Secunderabad.

- **Nova Biofuels, Panipat** to start biodiesel production its 30tpd plant at Panipat. Many small biodiesel production units ranging from 1tpd to 5 tpd are producing biodiesel.

- **Williamson Magor Bio-fuel Limited** has taken up plantation on contractual basis in 9 districts of Assam and so far covered 22,000 ha area.

Biodiesel Is Carbon Neutral

Biodiesel has a Closed Carbon Cycle; Therefore it does not Contribute to Global Climate Change

In the natural carbon cycle, there are two main processes that occur: photosynthesis and metabolism.

1. During photosynthesis, plants use carbon dioxide and produce oxygen
2. During metabolism, oxygen is used and carbon dioxide is a product

Humans impact this natural carbon cycle during the combustion of any type of fossil fuel, which may include oil, coal, or natural gas. Fossil Fuels were formed very long ago from plant or animal remains that were buried, compressed, and transformed into oil, coal, or natural gas. The carbon in fossil fuels is "fixed" in place and is essentially locked out of the natural carbon cycle. Humans intervene by burning the fossil fuels. During combustion, the hydrocarbon fossil fuels react with oxygen to form carbon dioxide and water molecules, which are released into the atmosphere.

The question becomes: What effect does this extra carbon dioxide have? There is considerable debate about the consequences the greenhouse gas effect may or may not have. The widely accepted fact is that human activities have changed the chemical composition of our global atmosphere through the buildup of greenhouse gases. The main greenhouse gases (GHGs) of concern are carbon dioxide (CO_2), nitrous oxide, and methane. Like glass on a greenhouse, these gases have heat-trapping capabilities. Carbon dioxide in particular has risen in our atmosphere since we began burning fossil fuels for energy.

Although global climate change is a hotly debated science, evidence shows an extremely strong correlation between increased carbon dioxide concentrations in our atmosphere and increased global temperature. Since the beginning of the industrial revolution, carbon dioxide concentrations have risen 30-35%. The Intergovernmental Panel on Climate Change (IPCC) reported in 2001 that carbon dioxide concentrations have increased from approximately 280 parts per million by volume (ppmv) in pre-industrial times to 367 ppmv in 1999. The IPCC also stated that "this concentration has not been exceeded during the past 420,000 years, and likely not during the past 20 million years. The rate of increase over the past century is unprecedented." The IPCC has zero doubt that the "the present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2." Anthropogenic emissions are those caused by human activity.

In 2003, petroleum emissions amounted to 2,500 million metric tons of CO_2. Although coal produces the most CO_2 per unit of energy gained, petroleum is currently producing the most CO_2 emissions because of consumption increases. In 1999, the transportation sector overtook the industrial sector as the largest source of atmospheric energy-related

CO_2. Between 1990 and 2002, on-highway vehicle miles traveled increased by 32 percent and between 1990 and 2003, transportation CO_2 grew by 19%.

Greenhouse gas emissions per unit of GDP did decline by 21.3 percent and CO_2 emissions per unit of GDP declined by almost 19% in the same time frame of 1990-2002. A major reason for the decline in greenhouse gas emissions is improvement in vehicle technologies. Engineers are designing more efficient, cleaner vehicles. However, the percentage of vehicle miles traveled has increased dramatically, and mobility and convenience are important American values. As a result, the overall CO_2 emitted has increased. Transportation related carbon dioxide is one of the predominant sources of energy-related U.S. greenhouse gas emissions. This becomes even more apparent when energy-related CO_2 emissions are represented graphically:

In general, biodiesel decreases carbon dioxide and methane emissions. In theory any fuel produced entirely from biomass can have a closed carbon cycle since all of the carbon within the fuel came from the plants it was made from, and the carbon in the plants came from the atmosphere. As Figure 7 shows, when plants grow they take CO_2 from the air to make the stems, roots, leaves, and seeds. Oil from the seeds is converted to biodiesel, which when burned produces CO_2 and other emissions, which returns to the atmosphere. This cycle does not add to the net CO_2 concentration in the air because the next. for example, soybean crop will reuse the CO_2 in order to grow. Since fossil fuels are normally still used to produce biodiesel, the recycling of CO_2 with biodiesel is not 100%, but substituting biodiesel for petroleum diesel reduces life-cycle CO_2 emissions by 78%. A 20% biodiesel, 80% petroleum blend reduces CO_2 by almost 16%. The percentages may seem low but they equate to huge numbers! In contrast, petrodiesel requires 100% new CO_2 to make and emits another 100% more when used. The petrodiesel life cycle emits 178% more CO_2 than biodiesel.

The Jatropha trees take 4 to 5 years to mature fully. At that time, if Jatropha Plantation is rain fed, these plants can yield 0.35 to 0.375 gallon of oil per tree or 375 gallons per hectare or 150 gallons per acre. If it is irrigated (3 to 5 liters per plant every 15 days) it can be double this amount.

According to the U.N., harvesting Jatropha requires 1 worker for every 1 acre of Land. Currently most the seeds produced in India, are sorted and used for either Plantation Purposes or for Crushing for oil. About 80% of the seeds are used for Plantations all over the world. This trend is likely to continue for next five years. About 20% seeds are crushed and oil is used for manufacture of Soap (Palm oil is now too expensive for soap) and as Lamp Oil in Hindu Houses and Temples. This is likely to continue for another few years. Currently no oil is available for BioDiesel and may be available after few years.

Plantation of Jatropha alone is not economically attractive, as there is little income from it for first 2 to 3 years. As Jatropha plant is initially small in height, Castor is intercropped with it in Fallow Land, to get income and oil for first 2 to 3 years. This oil can be used for lighting homes. (see Castor). If land is good, soy can be grown, as soy oil is edible oil and soy meal is cattle feed. It can fetch more income than castor.

Jatropha Plantations are doing well in India due to 4 reasons

1. India is densely populated country and the Fallow land holding per farmer is 1 to 10 acres. A family of farmer can take care of this size of land very easily, as far as plantation, harvesting as well as security is concerned. The infrastructure of Roads, Housing, Market is already there in Farmer's village. This infrastructure substantially reduces cost, as compared to plantations on barren, vast, unhabited lands.
2. Most of the farming in India is Organic by default. Cow dung is used as manure for Jatropha, and it is the cow dung which has done all the difference in low mortality of saplings, good yield, less pests etc. (In India there are 1 cattle for every 5 persons, 200 million cattle for 1 billion persons)
3. In India, the day to day expenses are quite low and a daily per capita income of US$ 2, in rural areas, is good enough for survival. This makes indian farmer, far more competitive as compared to farmers in developed world.
4. The prices of Petroleum Products in India, are around US$ 1 per liter. If it is less than this, there is no incentive to farmers to grow Jatropha.
5. **Seeds** : The seeds become mature when the capsule changes from green to yellow, after two to four months from fertilization. The blackish, thin shelled seeds are oblong and resemble small castor seeds. **Production of Seeds and oil** : From the experience in India and elsewhere, a plant density of 1,100 per hectare (spacing of 3 X 3 meters) has been found to be optimal, although in rain fed areas on poor soils a lower plant density of 1,666 has been felt to be more desirable. In such plantations Jatropha gives about 2 kgs of seed per tree. In relatively poor desert soils, such as in Kutch (Gujrat) the yields have been reported to be 1 kg per plant. The seed production in plantations varies between 2.5 tons / hectare and 5 tons / hectare, depending upon whether the soils are poor or average. (Some people claim that you can get 12 tons per hectare. This is not possible as 2 meters tall jatropha plant can not bear more than 1 kg of seeds per season initially. This level of production may be possible from a 10 year old jatropha plant.) If planted in hedges, the reported productivity of Jatropha is from 0.8 kg. to 1.0 kg. of seed per meter of live fence. Assuming a square plot, a fence around it will have a length of 400 sq. meters and a production of 0.4 MT of seed. A hedge along one hectare will be equal to 0.1 hectare of block plantation. The seed production is around 3.5 tons / hectare / annum. Oil content varies from 28% to 30% and 94% extraction, one hectare of plantation will give 1.6 MT of oil if the soil is average, 0.75 MT if the soil is lateritic, and 1.0 MT if the soil is of the type found in Kutch (Gujarat). One hectare of plantation on average soil will on an average give 1.6 Metric Tons of oil. Plantation per hectare on poorer soils will give 0.9 MT of oil. It can meet a number of objectives such as meeting domestic needs of energy including cooking and lighting, as an additional source of household income and employment, bio fertilizer, medicines, and industrial raw material for soap, cosmetics, etc. In creating environmental benefits, protection of

crops or pasture lands, or as a hedge for erosion control, or as a windbreak and a source of organic manure. **Ecological Requirements** : Jatropha curcas / Castor grows almost anywhere – even on gravelly, sandy and saline soils. It can thrive on the poorest stony soil. It can grow even in the crevices of rocks. The leaves shed during the winter months form mulch around the base of the plant. The organic matter from shed leaves enhance earth-worm activity in the soil around the root-zone of the plants, which improves the fertility of the soil. Climatically, Jatropha curcas / Castor is found in the tropics and subtropics and likes heat, although it does well even in lower temperatures and can withstand a light frost. Its water requirement is extremely low (1 liter per plant per day and can be provided once in 15 days which costs Rs. 20 per hector for each watering) and it can stand long periods of drought by shedding most of its leaves to reduce transpiration loss. Jatropha curcas is also suitable for preventing soil erosion and shifting of sand dunes.

Chapter-6

RESULTS OF RPOJECT

Economic aspects

Biomass utilisation for energy benefits local and regional economic development through job creation in rural areas on continued basis, foreign exchange saving from reduced oil imports, development of alternative markets for biomass products, and generation of tax revenue for governments.

Employment generation was found to be a common benefit from biomass-based industries especially in the services sector. In terms of the macroeconomic indicator, i.e. GDP, a generally positive trend with increase in bioenergy share was observed. Net fossil fuel importing economies not only could save fuel dollars but also would be able to diversify their energy resources giving them long term energy security. Some estimation of benefits from biomass production and its conversion into energy were made through a case study of the Philippines, which assessed economic impacts at a micro level. The study assessed the economic impacts in terms of value addition, job creation, tax revenue generation, and foreign exchange savings and earnings. The overall economic impact of the biomass-based industries was found to be significant not only at the provincial or regional level within the country but also to the national economy as a whole. The potential economic benefits of biomass energy are extensive. This study has revealed a generally positive trend in the macroeconomic indicator (GDP) with increase of biomass energy share. In addition, a number of employment opportunities can be achieved from the industry.

Social aspects

East Asian country governments are giving lot of impetus for the promotion of bioenergy and biofuels. In most of the countries a blending rate for biofuels has been proposed in the range of 5-10% in the short term with a long term target of 20%. As the demand for biofuels increases, production of biomass has to be increased, proportionately. Large scale cultivation of biofuel crops such as Jatropha, Coconut, Oil Palm, Sugarcane, etc. in East Asian countries is expected to generate millions of jobs in the farm sector and rural areas. With the help of a case study of India, it is revealed that to achieve 20% blending targets for biodiesel, Indian government hopes to increase Jatropha plantation up to 11.2 million hectares by 2011-12, with a job creation potential of about 311 man-days per hectare per year. Similarly, in case of ethanol, blending targets of 5-20%, by increasing sugarcane production, has a potential of creating jobs of 183 man-days per hectare per year. In addition, employment opportunities will be created in other stages of biofuel development chain. Marginal income increase due to employment in bioenergy programmers showed positive impact on other parameters of social development and overall improvement in living standards of people in the region. Among the negative impacts of bioenergy, "food versus fuel debate" may be the most crucial issue for East Asian Countries. For long-term sustainability of biofuel programmers and to reduce their negative impacts, use of waste lands for growing biomass, use of agro-residue for bioenergy, use of non-edible oil for biodiesel and, depending upon the fluctuation in domestic sugar demand, use of both molasses and sugarcane juice for ethanol production could be the right strategies.

Environmental aspects

Along with the decreased use of fossil fuels, biomass is expected to contribute to mitigating climate change by reducing GHG emissions. However, this environmental advantage can be realized only if sustainable practices are in place. The most important step is to prevent the clearance of large tropical forests for the sake of growing biomass. Also it is necessary to avoid the overdose of artificial fertilizers that will result in nitrous oxide emissions, another greenhouse gas. It should be ensured that the harvesting rates of the biomass resources are not higher than the growing capacity of the agricultural land producing it. Sustainable agricultural land management will help to promote the carbon neutral (or in some cases carbon negative) effects of bioenergy. The WG asserts a conservative approach to biomass utilization for energy production. A useful measurement is the carbon footprint of the system, where the entire biomass-to-bioenergy production chain should be considered, including any additional energy and resources spent to grow, produce, and in some cases, transport the biomass feedstock by rail or roads. By analyzing the carbon footprint or by taking into consideration the entire life cycle of biofuel and assessing the GHG emissions from "field to fuel", a more Accurate account of GHG emissions i.e. net reduction or increase may be revealed.

Sustainability Indicators

The current impetus in the utilization of biomass for materials and energy has generated a serious debate vis-à-vis its impact on food security. Also, from a life cycle perspective, the advantages of biomass utilization for climate change mitigation are not as clear as were thought earlier. Hence, it is imperative to assess the sustainability of biomass utilization. To this end, indicators addressing ecological, economic and social sustainability need to be developed. A suite of such indicators has been proposed as an attempt to quantify the ecological viability, social desirability and economic feasibility of biomass systems. Ecological indicators include thermodynamic metrics based on mass and energy balances and environmental metrics comprising carbon footprint, eutrophication, land use and biodiversity. Economic indicators incorporate income generation and energy security. The lack of quantifiable indicators for social sustainability was evident pointing to a need for further research in this important area.

4. POLICY RECOMMENDATIONS

Biomass production and utilization for energy involve complex issues that may have significant implications on the economies within the East Asia region. Sustainable utilization of biomass should consider economic, environmental and social aspects. Based on the current findings of the WG, and the accepted benefit of biomass as a source of renewable energy that will reduce the rate of depletion of fossil fuels, following recommendations have been proposed for the 'Sustainable Biomass Utilisation Vision in East Asia.'

(1) Addressing Macro and Micro Levels Needs to Reap Maximum Economic Benefits
The economic impact of biomass utilization should be considered from both macro-level and micro-level perspectives. This takes into account the economic benefit at national level, and its financial sustainability within the local economy. Regulations and subsidies are only short-term advantages, and therefore, the policies that will distribute the economic benefits to each stakeholder along the value-added chain of biomass energy, and also encourage growth of its supporting industries are favorable approaches.

(2) Enhancing Positive and Mitigating Negative Environmental Impacts
Agriculture activities are dominant contributors to the environmental impacts of biomass utilization. Policies and strategies should be framed to enhance the positive impacts and minimize the negative impacts. The entire life cycle of the process should be considered to identify environmental hot spots or activities that result in the most extensive damage from a particular impact. The action plan to minimize negative impact should be prioritized according to the extent of damage of the hot spot on the environment.

(3) Realizing Direct and Indirect Societal Benefits or Returns
Societal impacts include direct monetary benefits as in job creation and indirect monetary benefits in the form of better health and increased literacy and gender equality, etc. Societal benefits vary with their role in the value chain and this
Variation should be considered in policy framing. Policies must be developed to ensure that food security is not threatened at the expense of energy security and should be designed in such a way that they benefit all strata of the society.

(4) Developing Sustainability Indicators to Enhance the Decision Making Process
Sustainable development indicators should address ecological, economic and social sustainability. Currently, there is no single indicator to integrate all three aspects and a suitable indicator for the same is yet to be developed. However, every indicator need not to be applied in the decision making process. Harmonization of indicators at the regional level, development of indicators that can integrate all three aspects and indicators that can address complex issues such as energy security should be actively pursued.

(5) Using Appropriate Tools to Generate Quantifiable and Verifiable Life Cycle Information
Appropriate evaluation tools or techniques will enable the generation of quantifiable information and data for use by the indicators. Life Cycle Assessment (LCA) is an established tool that can provide life cycle footprints for critical environmental impact categories. The use of LCA will also ensure those negative impacts are not passed from one environmental compartment to another, from one time frame to another, or from one region to another.

(6) Considering Country-Specific Needs and Available Biomass Resources
Depending on the country's experience and needs, the driving force to propagate the biomass energy industry can be economic, environmental or social factors, or a combination of these factors. Careful assessment should be conducted to ensure that the decisions and actions are in accordance with the priorities of the country.

(7) Promoting Regional and International Cooperation
Within the East Asian region as well as at international level, each country should pay due attention to the policies and approaches that are adopted by other Countries. Collaboration between bioenergy producing and bioenergy consuming countries in East Asia, including technology exchange, capacity building and appropriate pricing, should be given priority for sustainable biomass utilities

Biodiesel Scenario In India

As India is deficient in edible oils, non-edible oil is the main choice for producing biodiesel. According to Indian government policy and Indian technology effects. Some development works have been carried out with regards to the production of transesterfied non edible oil and its use in biodiesel by units such as Indian Institute of Science, Bangalore, Tamilnadu Agriculture University Coimbatore and Kumaraguru College of Technology in association with Pan horti consultants. Coimbatore. Generally a Blend of 5% to 20% is used in India (B5 to B20). Indian Oil Corporation has taken up Research and development work to establish the parameters of the production of tranesterified Jatropha Vegetable oil and use of bio diesel in its R&D center at Faridabad. Research is carried out in Kumaraguru College of Technology for marginally altering the engine parameters to suit the Indian Jatropha seeds and to minimize the cost of transesterification.

Chapter-7

Indian Biodiesel Program

- Name of Biodiesel started making appearance at Indian Seminars in 2000
- 'Report of the Committee on Development of Biofuel' – Planning Commission, GOI
- Emphasized on Biodiesel
- Recommended Stage I 'Demonstration Project' use Jatropha curcas on 400,000 ha (0.5 Mill T BD) Nation-wide investment $ 300 mill
- Recommended Stage II – 11 mill ha (13 mill T biodiesel) for 20% blend.

Indian Biodiesel Program

- Large number of small inefficient plants set up more as pilot plants
- Shortage of feedstock's.
- However, in 2005-06 estimated 125,000 ha of Jatropha planted
- Demonstration project started with initial grant of $11mill for nursery raising rest expected this year
- First 10,000 TPA plant expected production by Q3
- 100,000 TPA plant construction started
- Another 100,000 TPA DMT plant proposed to be modified
- Research on Jatropha being taken up 34 Agri univ & R&D centers

Challenges

- Vision and Policy
- Constraint on availability of feedstock
- Import of feedstock (CPO) not encouraged as can be (mis)used in edible oil
- Indian farmer protected by high tariff of nearly 80%
- How to balance production of feedstock and oil extraction and Biodiesel?
- Jatropha cultivation not well documented or researched – high yield varieties to be created, package of practices to be finalized for each agro-climatic zone.
- Comparison with other non-edible oil seeds to be done

Indian Biodiesel Potential

- 10 to12 mill Ha of degraded lands can provide Biodiesel for 20% blend (12 mill Tonnes per year).
- Biodiesel with a potential consumption of 15000 million liters can have a retail turnover of more than Rs 450, 000 million per year.
- It can provide huge rural employment potential of 40 to 50 million families and transform the rural economy

- Remote village electrification and power for agriculture application – Energy grown & used by village.
- Max benefit to rural economy

CDM Benefits to Indian Economy

- Afforestation/Reforestation – carbon sequestration - 12 mill ha – 120 mill tonnes CO2
- Earning potential @ $5/T - $ 600 mill
- Per tonne of Biodiesel used the potential reduction of CO2 is estimated to be between 2.5 tones (USA) to 3.0 tonnes of CO2 per tonne per tonne used depending on Soya and Jatropha
- For 10 mill tonnes Biodiesel production by 2012, potential reduction of CO2 of about 251,000 tonnes
- Earning potential for India by the year 2012 in carbon trading (CERs) - US$ 125 million

Biodiesel Emerges as a Global Industry

"The global markets for biodiesel are entering a period of rapid, transitional growth, creating both uncertainty and opportunity. The first generation biodiesel markets in Europe and the US have reached impressive biodiesel production capacity levels, but remain constrained by feedstock availability. In the BRIC nations of Brazil, India and China, key government initiatives are spawning hundreds of new opportunities for feedstock development, biodiesel production, and export" said Biodiesel 2020 author Will Thurmond.

"A fundamental transition in global fuel production is now happening. In the year 2007, there were only 20 oil producing nations supplying the needs of over 200 nations. By the year 2010, more than 200 nations will become biodiesel producing nations and suppliers," said Thurmond. "The world is entering a new era of participation by emerging market nations in global green energy production for transport fuels."

Potential and advantages of Bio diesel

- Blends of 20% biodiesel with 80% petroleum diesel can be used in unmodified diesel engines. Biodiesel can be used in its pure form but many require certain engine modifications to avoid maintenance and performance problems.
- It was stated that about half of the biodiesel industry can use recycled oil or fat, the other half being soybean, or rapeseed oil according to the origin of these feed stocks.
- Biodiesel is nontoxic, biodegradable. It reduces the emission of harmful pollutants (mainly particulates) from diesel engines (80% less CO_2 emissions, 100% less

sulfur dioxide) but emissions of nitrogen oxides (precursor of ozone) are increased.

- Biodiesel has a high cetane number (above 100, compared to only 40 for diesel fuel). Cetane number is a measure of a fuel's ignition quality. The high cetane numbers of biodiesel contribute to easy cold starting and low idle noise.
- The use of biodiesel can extend the life of diesel engines because it is more lubricating and, furthermore, power output are relatively unaffected by biodiesel.
- Biodiesel replaces the exhaust odor of petroleum diesel with a more pleasant smell of popcorn or French fries.

By developing methods to use cheap and low quality lipids as feed-stocks, it is hoped that a cheaper biodiesel can be produced, thus competing economically with petroleum resources.

Biodiesel has many environmentally beneficial properties. The main benefit of biodiesel is that it can be described as 'carbon neutral'. This means that the fuel produces no net output of carbon in the form of carbon dioxide (CO2). This effect occurs because when the oil crop grows it absorbs the same amount of CO2 as is released when the fuel is combusted. In fact this is not completely accurate as CO2 is released during the production of the fertilizer required to fertilize the fields in which the oil crops are grown. Fertilizer production is not the only source of pollution associated with the production of biodiesel, other sources include the esterification process, the solvent extraction of the oil, refining, drying and transporting. All these processes require an energy input either in the form of electricity or from a fuel, both of which will generally result in the release of green house gases. To properly assess the impact of all these sources requires use of a technique called life cycle analysis. Biodiesel is rapidly biodegradable and completely non-toxic, meaning spillages represent far less of a risk than fossil diesel spillages. Biodiesel has a higher flash point than fossil diesel and so is safer in the event of a crash.

Biodiesel is better for the environment because it is made from renewable resources and has lower emissions compared to petroleum diesel. It is less toxic than table salt and biodegrades as fast as sugar.

ENVIRONMENT AND SAFETY:

Scientists believe carbon dioxide is one of the main greenhouse gases contributing to global warming. Neat Biodiesel (100% Biodiesel) reduces carbon dioxide emissions by more than 75% over petroleum Diesel. Using a blend of 20% Biodiesel reduces carbon dioxide emissions by 15%. Biodiesel also produces fewer particulate matter, carbon monoxide, and sulphur dioxide emissions (all air pollutants under the Clean Air Act).

The use of Biodiesel has significant benefit when it comes to supporting the environment. Biodiesel is the first and only alternative fuel to have a complete evaluation of emission results and potential health effects submitted to the U.S. Environmental

Protection Agency (EPA) under the Clean Air Act Section 211(b). These programs include the most stringent emissions testing protocols ever required by EPA for certification of fuels or fuel additives in the US. The data gathered through these tests complete the most thorough inventory of the environmental and human health effects attributes that current technology will allow. A survey of these results is provided in the table below. The overall ozone (smog) forming potential of Biodiesel is less than Diesel fuel. The ozone forming potential of the speciated hydrocarbon emissions was nearly 50 Percent less than that measured for Diesel fuel.

Sulphur emissions are essentially eliminated with pure Biodiesel. The exhaust emissions of sulphur oxides and sulfates (major components of acid rain) from Biodiesel were essentially eliminated compared to sulphur oxides and sulphates from Diesel. Criteria pollutants are reduced with Biodiesel use. The use of Biodiesel in an unmodified Cummins N14 Diesel engine resulted in substantial reductions of unburned hydrocarbons, carbon monoxide, and particulate matter. Emissions of nitrogen oxides were slightly increased.

Carbon Monoxide -- The exhaust emissions of carbon monoxide (a poisonous gas) from Biodiesel were 50 percent lower than carbon monoxide emissions from Diesel.

Particulate Matter -- Breathing particulate has been shown to be a human health hazard. The exhaust emissions of particulate matter from Biodiesel were 30 percent lower than overall particulate matter emissions from Diesel.

Hydrocarbons -- The exhaust emissions of total hydrocarbons (a contributing factor in the localized formation of smog and ozone) were 93 percent lower for Biodiesel than Diesel fuel.

Nitrogen Oxides -- NOx emissions from Biodiesel increase or decrease depending on the engine family and testing procedures. NOx emissions (a contributing factor in the localized formation of smog and ozone) from pure (100%) Biodiesel increased in this test by 13 percent. However, Biodiesel's lack of sulphur allows the use of NOx control technologies that cannot be used with conventional Diesel. So, Biodiesel NOx emissions can be effectively managed and efficiently eliminated as a concern of the fuel's use.Biodiesel reduces the health risks associated with petroleum Diesel. Biodiesel emissions showed decreased levels of PAH and nitrited PAH compounds which have been identified as potential cancer causing compounds.

In the recent testing, PAH compounds were reduced by 75 to 85 percent, with the exception of benzo(a)anthracene, which was reduced by roughly 50 percent.

SAFETY

1- When making Biodiesel, it's important to be safe. Because we are dealing with toxic chemicals, the potential to seriously hurt, injure, and even kill our self and others exists. This site and its contributors will not be held responsible for any injury, death, or destruction of property that occurs while attempting to make Biodiesel. BE SAFE WHEN MAKING BIODIESEL.

2- we'll be dealing with some fairly caustic chemicals, an alcohol called Methanol, fair amounts of heat, and the transferring of flammable fluids from one container to container so it's a good idea to have a fire extinguisher around that is capable of putting out an oil based fire.

3- Biodiesel should **always** be made in a well-ventilated area away from children and pets with the proper safety equipment utilized.

4- Before making large batches of Biodiesel, check with our local municipality and fire marshall to ensure that any chemicals, alcohol, or other substances you will use are being stored and used within the proper laws and ordinances for your area. Some area's refer back to state and federal fire codes. It's always a good idea to check before you get started.

5- Using home made Biodiesel in a diesel engine vehicle may void our manufacturer's warranty. Although the steps outlined to make it are fairly bullet proof and have been tested in several thousands of vehicles all over the world, there's no guarantee your engine manufacturer will honor our warranty.

6- Biodiesel is considered a fuel so if you plan to use it in a vehicle for on-road use, it may be subject to taxes. Check with our state and federal taxing agencies if in question.

7- Biodiesel itself, when properly made, is actually quite safe. It's less toxic than table salt and degrades faster than sugar. It has a higher flash point (point at which it ignites) than regular petrodiesel and if spilled isn't considered toxic.

Chapter-8

Biodiesel – The Opportunities and Challenges

Potential for Biodiesel

Biodiesel is presently produced from the esterification of lipid materials (fats and oils), such as soy oil in the United States and rapeseed oil in Europe. Canada produces vast quantities of canola (rapeseed), along with, to a lesser extent, other oil crops such as soy, mustard and corn. Canada is a net exporter of canola oil and non-crushed canola seed, making canola the likely initial source for virgin oil esterification biodiesel feedstock domestically. Biodiesel can also be produced conventionally from other natural fats and oils, such as tallow, grease, and used cooking oil. Canada is a net exporter of tallow and grease, providing another potential domestic feedstock for production. Current issues related to restrictions on rendered animal products for animal and human feed materials (i.e., from risks associated with Bovine Spongiform Encephalopathy (BSE) and other animal diseases) have resulted in a potential increased availability of these materials that could be utilized for biodiesel production. The Canadian General Standards Board has now recognized ASTM D6751 (USA biodiesel specification – Standard Specification for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels; ASTM, 2003) as part of its new CGSB-3.520 specification: Automotive low sulphur diesel fuel containing low levels of biodiesel esters (B1 – B5). This industry-accepted specification recognizes only alkyl esters of lipids as biodiesel, which are produced by esterification.

Other bio-based diesel fuels, including Super Cetane and Fischer-Tropsch synthesis products are currently not included in biodiesel standards. An inventory of the main Canadian lipid feedstocks provides a general assessment of the preliminary potential for conventional biodiesel production the major cropped lipid source in Canada is canola oil extracted from canola seed. It is important to note that of the approximately 6 MT of canola seed that will be harvested in 2003-2004 (USDA, 2003 and Canadian Canola Council, 2004), 50% will be exported as raw seed while 2.5 MT seed will be crushed domestically to yield 1.05 MT canola oil (42% oil yield from seed). Therefore, exported seed represents an additional potential oil yield of 1.3MT. Some 0.29 MT of animal tallow and grease are produced in Canada each year of which 85 % is typically exported.

However, current restrictions on the use of these materials may increase availability of some animal lipids for biodiesel feedstock from reduced exportation. Soy oil imports exceed exports and without significant increases in soy production, this is not presently regarded as a key potential biodiesel feedstock. Two additional oil crops that could be considered are mustard and flax, although currently, both have Canadian production volumes far below canola. A preliminary case-study analysis for utilizing Canada's existing lipid feedstock's for biodiesel production to meet a B5 requirement, i.e., biodiesel production to 5% of Canada's current transportation petroleum diesel consumption (a requirement for 0.54 MT biodiesel or approximately 610 million liters/yr), was conducted (see Table 3). This scenario involves both increased production and diversion of currently exported lipid materials. To make such a significant market-driven contribution to diesel fuel supply, substantial production increases (e.g., 10% increase in canola production) and export diversion (e.g. 50% diversion of animal lipids and canola oil) would be required. On a volume basis, canola oil and animal lipids show the greatest resource from which to base an emerging Canadian biodiesel industry. This is due to the underutilized capacity for additional canola oil production from domestic crushing of currently exported harvested seed and changing policy constraints of animal lipid use in their traditional markets.

Biosolids and Carbon Sequestration An opportunity

- To get publicity for the overwhelming good associated with residuals reuse.
- Potentially a more practical way to integrate residuals from the urban sector with the agricultural community (my original career goal).

The Advantages of Bio Diesel

- Bio Diesel is the most valuable form of renewable energy that can be used directly in any existing, unmodified diesel engine.
- **Energy Independence:** Considering that oil priced at $60 per barrel has had a disproportionate impact on the poorest countries, 38 of which are net importers and 25 of Which import all of their oil; the question of trying to achieve greater energy independence one day through the development of biofuels has become one of 'when' rather than 'if,' and, now on a near daily basis, a biofuels programmed is being launched somewhere in the developing world.
- **Smaller Trade Deficit:** Rather than importing other countries' ancient natural resources, we could be using our own living resources to power our development and enhance our economies. Instead of looking to the Modest for oil, the world could look to the tropics for biofuels. producing more biofuels will save foreign exchange and reduce energy expenditures and allow developing countries to put more of their resources into health, education and other services for their neediest citizens.
- **Economic Growth:** Biofuels create new markets for agricultural products and stimulate rural development because biofuels are generated from crops; they hold enormous potential for farmers. In the near future—especially for the two-thirds of the people in the developing world who derive their incomes from agriculture.

  Today, many of these farmers are too small to compete in the global market, especially with the playing field tilted against them through trade distorting agricultural subsidies. They are mostly subsistence farmers who, in a good year, produce enough to feed their families, and in a bad year, grow even poorer or starve. But biofuels have enormous potential to change this situation for the better.

- **Cleaner Air:** Biofuels burn more cleanly than gasoline and diesel. Using biofuels means producing fewer emissions of carbon monoxide, particulates, and toxic chemicals that cause smog, aggravate respiratory and heart disease, and contribute to thousands of premature deaths each year.

- **Less Global Warming:** Biofuels contain carbon that was taken out of the atmosphere by plants and trees as they grew. The Fossil fuels are adding huge amounts of stored carbon dioxide (CO_2) to the atmosphere, where it traps the Earth's heat like a heavy blanket and causes the world to warm. Studies show that biodiesel reduces CO_2 emissions to a considerable extent and in some cases all most nearly to zero.

- Requires no engine modifications (except replacing some fuel lines on older engines).
- Can be blended in any proportion with petroleum diesel fuel.
- High cetane number and excellent lubricity.
- Very high flashpoint (>300°F)
- Can be made from waste restaurant oils and animal fats
- Lower tailpipe emissions

<u>In Nut-shell:</u>

- Bio Diesel is the most valuable form of renewable energy that can be used directly in any existing, unmodified diesel engine.
- Bio Diesel fuel and can be produced from oilseed plants such as rape seeds, sunflower, canola and or <u>JATROPHA CURCAS</u>.
- Bio Diesel is environmental friendly and ideal for heavily polluted cities.
- Bio Diesel is as biodegradable as salt.
- Bio Diesel produces 80% less carbon dioxide and 100% less sulfur dioxide emissions. It provides a 90% reduction in cancer risks.
- Bio Diesel can be used alone or mixed in any ratio with mineral oil diesel fuel. The preferred ratio if mixture ranges between 5 and 20% (B5 - B20) .
- Bio Diesel extends the live of diesel engines.
- Bio Diesel is cheaper then mineral oil diesel.
- Bio Diesel is conserving natural resources.

<u>Global Warming</u>

- Biodiesel has a (nearly) closed carbon cycle.
- Biodiesel yields a 78% carbon dioxide (CO_2) reduction compared to petroleum diesel under petroleum life cycle analysis.
- Biodiesel has the most favorable energy balance of any liquid fuel.

Biodiesel vs. Petroleum Diesel

Emission	B100	B20
Carbon mono oxide	-47%	-12%
Hydrocarbon	-67%	-20%
Particulate matter	-48%	-12%
Sulphate	-100%	-20%
Nitrogen-di-oxide		
Ozone	-50%	-10%
PAH	-80%	-13%

Biodiesel Impact

An important factor that is not usually considered when calculating the costs and benefits of industrial feedstock materials is the macroeconomic effect associated with domestically produced, renewable energy sources. Economic benefits of a biodiesel industry in the US would include value added to the feedstock (oilseeds or animal fats), an increased number of manufacturing jobs, an increased tax base from plant operations and income taxes, investments in plant and equipment, improvement of our trade balance, and reductions in health care costs due to improved air quality and greenhouse gas mitigation.

Biodiesel has positive impacts on the state economy. An Iowa State University study concluded that three economic benefits would accrue to state from biodiesel. First, biodiesel expands demand for soybean oil, causing processors to pay more for soybeans, In addition, soybean farmers near the biodiesel plant would receive slightly higher prices for soybeans; and third, the presence of a facility that creates energy from soybeans would add value to the state's industrial and income base.

Dr. Hayes concluded that, "If the state of Iowa were to mandate the use of a 20 percent biodiesel blend in its state vehicle fleet where feasible, the total additional cost of this policy would range from $400,000 to $500,000. If it could be shown that this policy would result in a new five million gallon biodiesel plant in the state, then the policy would create more new tax revenues than it would cost and would clearly be in the best interest of the state."

Biodiesel has positive implications for production agriculture. A 1996 economic study published by the USDA Office of Energy predicted that a modest, sustained annual market for biodiesel of 100 million gallons in the US would contribute approximately seven cents to the price of each bushel of soybeans produced in the US. Based on last year's harvested crop, the increase could have resulted in more than $168 million directly to the use of biodiesel.

Biodiesel has a positive impact on the US balance of trade. A 1998 biodiesel lifecycle study jointly sponsored by the US Department of Energy and the US Department of Agriculture concluded that increased use of biodiesel and biodiesel blended fuels such as B20 would substantially benefit our economy. The report concluded that national spending to import petroleum sends significant amounts of dollars out of our domestic economy every year. Biodiesel offers the potential to shift this spending from foreign imports to domestically produced energy. The report notes: "With its ability to be used directly in existing diesel engines, biodiesel offers the immediate potential to reduce our demand for petroleum in the transportation sector."

Biodiesel contributes jobs to the local economy. Economic work conducted at the University of Missouri estimated the benefits of producing biodiesel in a metropolitan region. This study concluded that 100 million gallons of biodiesel production could generate an estimated $8.34 million increase in personal income and over 6,000 additional temporary or permanent jobs for the metropolitan region.

Disadvantages of biodiesel-

1-Lower Energy Content
8% fewer BTU's per gallon, but also higher cetane #, lubricity, etc.
2-Poor cold weather performance
This can be mitigated by blending with diesel fuel or with additives, or using low gel point feedstocks such as rapeseed/canola
3-Stability Concerns
Biodiesel is less oxidative stable than petroleum diesel fuel. Old fuel can become acidic and form sediments and varnish. Additives can prevent this
4-Scalability
5-Soybean oil-based biodiesel will start to crystallize at around 0°C. This can be mitigated by blending with diesel fuel or with additives.
6-Biodiesel is less oxidatively stable -than petroleum diesel fuel. Old fuel can become acidic and form sediments and varnish. Additives can prevent this.
7-Biodiesel can cause filter plugging (at low temps, due to polymers, fuel tank deposits, other contaminants). Frequent filtering can keep fuel clean.
8-Cost and feedstock supply are problems. Soybean oil is widely available but expensive. Inedible animal fats and waste greases are inexpensive but have limited supply.
10--D6751 fuel. Follow good fuel handling practices.
11-Biodiesel has 8% lower energy content. B20 users will see fuel economy and max power drop by about 1%-2%.
12-Biodiesel can gel at lower temperatures (like petroleum diesel). Blending and additives can control this.

Chapter-9

CONCLUSION-

As a substitute for fast depleting fossil fuel. Bio diesel had come to stay. In future, it should also serve to reduce and maintain the price of automobile fuel. The under exploited and un exploited vegetable oils are good sources of biofuel. Our country is endowed with many such plants. Research is being carried out now to convert vegetable oils into biodiesel through biotechnological processes using biodiesel. With a concentrated and coordinated effort. Wide use of bio diesel in our country is going to be a reality in the days to come.

Benefit of bio diesel-

1-It will be a major pro poor initiative generating massive income and employment.

2-It will be a major tool for achieving the emission standard approved by the government.

3-Address the concern of global warming under FCCC.

4-Improve the land resources through drought proofing greening of degraded land, soil and moisture conservation.

5-It had generated employment to 127.6 million man days in plantation and 36.8 million person days in seed collection.

6-Overall basis the income generated from the output of 1.5 million tones of seed will be Rs 750 crore the income derived from JATROPHA plantation and seed will be supplementary and assuming that the income from 1 hectare of plantation will be shared by 4 families.

A national mission on Bio-Diesel has already been proposed by the committee comprising six micro missions covering all aspects of plantation, procurement of seed, extraction of oil, trans-esterification, blending & trade, and research and development. Diesel forms nearly 40% of the energy consumed in the form of hydrocarbon fuels, and its demand is estimated at 40 million tons.

Therefore blending becomes the important National Issue which apart from giving the dividends, it saves the country's exchequer. India has vast stretches of degraded land, mostly in areas with adverse agro- climatic conditions, where species of Jatropha , Mahua etc can be grown easily.

Even 30 million hectares planted for bio- diesel can completely replace the current use of biofuels. The production of Bio fuels will also boost the rural economy which will bring more enthusiasm in more than one billion lives in the area

Resources are available to help farmers and consumers determine the best means to manage the advantages biodiesel has to offer. Biodiesel has "tailpipe benefits" and holds great promise as a sustainable energy source, if several sustainability principles are treated seriously:

1. Capture as much energy efficiency as possible on and off the farm, to reduce transportation fuel demand, reduce production costs, and improve energy balance.
2. Convert as much waste as possible into a useable resource, such as converting waste vegetable oil into fuel.
3. Put oil-producing crops and high-quality agricultural lands to their highest and most sustainable use, which will often be food production instead of energy production.
4. Raise bioenergy crops that enhance soil and water resources.
5. Create a range of diverse opportunities for biodiesel production in terms of the scale, design, and ownership so farmers and rural communities can share in the economic benefits.

RECOMMENDATION-

1-All the equipment should be tested periodically.

2-The quality of the final product should be up to the mark.

3-There should be a quality control and quality assurance laboratory in the exist lab.

4-The harmful pollutant should be checked and proper method of disposal should be found out.

5-If any engine modification is needed in the engine it should be properly be mentioned in engine.

REFERENCES

WWW.GOOGLE.COM

WIKIPEEDIA OF BIO DIESEL

WWW.BIODIESEL AND ENVIRONMENT

MANUALS OF AT BIO DIESEL LABROTARY IN UPES

An Overview of Biodiesel and Petroleum Diesel Lifecycles, May 1998, Sheehan, *et al.* NREL

Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus, 1998, Sheehan,

lanl.gov, Green Freedom: Out of Thin Air

ADM Biodiesel: Hamburg, Leer, Mainz

IEA bioenergy

http://www.renewable-energy-world.com/article

http://www.bio-productscanada.org/pdf/en_roadmap_book.pdf

bioenergy.ornl.gov/papers/misc/switchgrass-profile.html