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Biofuels and their future perspectives

ZI Buhroo, MA Bhat, NA Ganai and JA Lone

Abstract
Biofuel in today's scenario is becoming increasingly attractive fuel because of its environmental benefits and renewable nature. Continuous use of petroleum sourced fuels is now widely recognized as unsustainable because of depleting supplies and the contribution of these fuels to global warming by way of heavy accumulations of carbon dioxide in the environment. The soaring oil prices have encouraged major consumers worldwide to sharply increase the use of Biofuel. In a developing country like India this is not practically feasible to divert the edible oil for production of Biofuel as the edible oil demand for human consumption is always higher than its domestic production. Under Indian conditions only such plant sources can be considered for Biofuel which produces non-edible oil in appreciable quantity and can be cultivated at large scale on non cropped marginal and wastelands. There are many tree species which bear oil rich seeds and can serve as excellent feedstock for Biofuel production. Biofuel plants are specially grown to produce some form of energy which may be generated through direct combustion or gasification of the plants to produce electricity and heat or by converting them to liquid fuels such as ethanol or biodiesel for use in vehicles. Various raw materials used to produce biodiesel include soybean oil, rapeseed oil, Jatropha oil, palm oil, waste vegetable oil and animal fat etc. In India the major thrust is on Jatropha oil and the rest of raw material sources are extensively used in USA and other countries of the world. This is because Jatropha, a promising Biofuel crop can be grown on any type of land without much care and investment. Keeping in view the increasing global prices and the finite nature of traditional based fuels it is imperative to encourage the use of Biofuels. Apart from this there is a dire need to explore the other efficient Biofuel crops at large scale especially in India.

Keywords: Biofuels, environment, perspectives, applications, future

Introduction
The fuels that are derived from biological raw materials of plants and animals are known as Biofuels or any fuel that is derived from biomass i.e., plant material or animal waste. Biofuel are liquid or gaseous fuels derived from renewable biomass and sometimes may be solids also. Recent development towards more environmentally friendly energy production has made the use of biomass for energy more attractive. Production and use of standardized biofuels is expected to play an important role in the coming renewable energy development. Biofuel crops contribute a significant share of global primary energy consumption and their importance is likely to increase in future world energy scenarios. Current biofuel use, although not sustainable in some cases, replaces fossil fuel consumption and results in avoided CO_2 emissions, representing about 2.7 to 8.8% of 1998 anthropogenic CO_2 emissions. The global biomass energy potential is large, estimated at about 104 EJ/a. Hence, biofuels have the potential to avoid significant fossil fuel consumption, potentially between 17 and 36% of the current level and CO_2 emissions potentially between 12 and 44% of the 1998 level. Modern biofuel energy use can contribute controlling CO_2 emissions to the atmosphere while fostering local and regional development. There is significant scope to integrate biomass energy with agriculture, forestry and climate change policies. Further the advantages from utilization of biomass include liquid fuels produced from biomass contain no sulphur, thus avoiding SO_2 emissions and also reducing emissions of NOx. The creation of new employment opportunities within the community and particularly in rural areas will be one of the major social benefits.

Need to focus on Biofuels
The rapidly increasing demand of petroleum products for energy in the transport, industry, agriculture and other sectors has led to escalating prices and huge import bill. The reserves of fossil fuel are also depleting. The tremendous use of petroleum and diesel is responsible for alarming pollution of environment. Hence, alternative sources of energy for fulfilling the requirements are being considered worldwide.

- Increasing energy requirement
- Thrust on resource conservation
- Soaring oil prices
- Reducing availability
- Stringent environmental regulations

There are many potential benefits from the use of energy crops. The three benefits discussed in this section are: increased rural economic development, energy security, and environmental benefits. An additional environmental benefit from the use of energy crops is the habitat it provides for wildlife. A scientist from the National Audubon Society stated that such Energy crops may also protect natural forests by providing an alternative source of wood, which can be grown on farm or pasture land that is no longer suitable for traditional row crops (due to crop surpluses or overworked land). Using crops for energy will create additional markets for crops and a new source of income for farmers, put underutilized land to use, create environmental and energy security benefits, and provide employment opportunities.

Environmental Benefits

Environmental benefits from the use of energy crops include water quality improvements, emission decreases at generation facilities, and wildlife habitat improvements over traditional crops. Water & soil improvements Energy crops act as filter systems, removing pesticides and excess fertilizer from surface water before it pollutes groundwater or streams/rivers. Because of these filtering capabilities, energy crops are being considered as a supplemental crop to be planted with traditional crops for pollution control. An ORNL article on the use of energy crops for pollution control stated that a buffer zone of trees or grass only 22 yards wide can protect a "stream's bank and water from erosion, siltation, and chemical runoff" and can still be harvested for energy.

Most energy crops also require less fertilizers, herbicides and insecticides than traditional row crops. The reduction in herbicide and pesticide use reduces the potential for water pollution and other environmental problems due to nonpoint source pollution.

ORNL has concluded that, "any change from annual to perennial herbaceous or woody crops will reduce groundwater and surface-water contamination significantly". Research has also shown that energy crops have "increased soil stability, decreased surface water runoff, decreased transport of nutrients and sediment, and increased soil moisture", in comparison to traditional crops.

The Union of Concerned Scientists has stated that, "converting a corn farm of average size to switch grass could save 66 truckloads of soil from erosion each year". The soil erosion benefits of energy crops may be of particular interest to certain areas in Michigan. The USDA National Resources Inventory has listed 557,300 acres in the state as having "high potential for soil erosion.

Emission Reduction Another environmental benefit from the use of energy crops versus fossil fuels for energy production is a decrease in emissions. Unlike fossil fuels, plants grown for energy crops absorb the amount of carbon dioxide (CO_2) released during their combustion/use. Therefore, by using biomass for energy generation there is no net CO_2 generated because the amount emitted in its use has been previously absorbed when the plant was growing.

The amount of carbon emitted during energy production is considerably less for switch grass and some woody crops, such as poplar in comparison to natural gas, petroleum and coal. By 1994, 20% of the worldwide CO_2 emissions was generated by the United States. According to ORNL, "utility power plants account for 72% of SO2 [Sulfur dioxide], 35% of CO_2, and 33% of NOx [Nitrogen Oxide]" emissions in the United States. Coal power plants (which supply 74% of the electricity in the Midwest) are the worst contributor of these emissions. This problem is exacerbated by the fact that many of the Midwestern coal plants were built between 1940 and 1970 and therefore often don't have modern pollution control systems. ORNL reports that substituting biomass for coal as a fuel source would reduce emissions of these key pollutants. If approximately 35 million acres were used to grow energy crops and replace the use of coal for electric generation, it would eliminate 6% of annual CO_2 emissions in the United States. If a mix of 10% willow was co-fired with 90% coal, NOx and SO_2 emissions would be reduced by 10%.

Emissions from power plants have many environmental and health impacts. CO_2 contributes to global warming. SO_2 and NOx emissions contribute to acid rain and NOx also contributes to ground level ozone. Acid rain causes acidification of lakes and streams, which can kill fish. It can also cause significant damage to forests, vehicles, buildings and other structures. Reduced air quality due to emissions has also been linked to increases in respiratory ailments such as asthma. Total health care costs linked to air pollution were estimated by the American Lung Association to be 50 billion dollars a year.

Wildlife or Natural Habitat Benefits

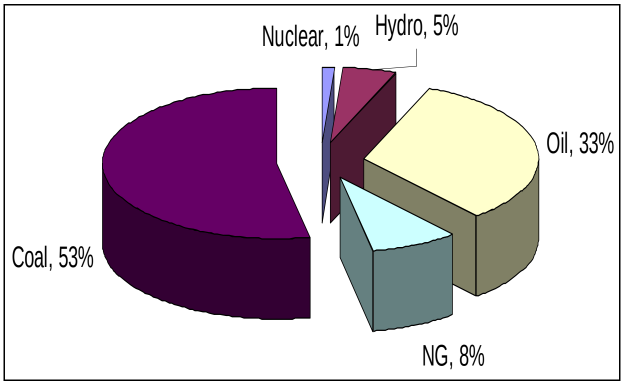
An additional environmental benefit from the use of energy crops is the habitat it provides for wildlife. A scientist from the National Audubon Society stated that such Energy crops may also protect natural forests by providing an alternative source of wood, which can be grown on farm or pasture land that is no longer suitable for traditional row crops (due to crop surpluses or overworked land). Using crops for energy will create additional markets for crops and a new source of income for farmers, put underutilized land to use, create environmental and energy security benefits, and provide employment opportunities.

With the projection that our electric generation needs will increase 33% and that 75% of our oil could be imported from foreign countries by 2010, it makes sense to look to renewable, non-fossil fueled based energy sources such as energy crops to meet new demand. The next section discusses some of the barriers and potential solutions for increased use of energy crops.

Energy Security

Energy generated through the use of energy crops would have the additional benefit of being a source of domestically produced, renewable energy. The use of energy crops to produce transportation fuels could increase our energy security by decreasing our dependency on foreign oil. (Our reliance on foreign energy sources is by far the largest in the transportation fuel sector.) Currently the U.S. imports more than 50% of the oil used for transportation fuels and the DOE estimates imports could increase to 75% by 2010. Dependency on foreign imports has significant economic and social costs. The costs of defending foreign oil supplies (such as in the Persian Gulf) are estimated to be $10-23 billion dollars a year.57 There are additional costs in maintaining the Strategic Petroleum Reserve, which consists of almost 590 million barrels of oil. At our current consumption rates, if all foreign imports were halted, the reserve would last about 75 days. The cost of maintaining this reserve is more than $200 million dollars a year.

Energy Sources - Indian Scenario
[India Hydrocarbon Vision, 2020]



Types of Biofuel

- BIOGAS – (Methane)
- BIOALCOHOL- (Ethanol)
- BIODIESEL

Plants for Biofuel extraction

Non-edible Plants: Jatropha, Castor, Mahua, Canola, Neem, Karanjia, Jojoba, Mint, Linseed.

Edible Plants: Sugarcane, Rapeseed, Sunflower, Palm oil, Soyabean, Molasses, Sugarbeat, Maize, Wheat, Barley, Potato, Peanut, Hemp, Coconut, Groundnut.

Gasification Technology

A process that uses heat, pressure, and steam to convert materials directly into a gas composed primarily of carbon monoxide and hydrogen. Gasification is a two-step process involves Oxidation and Reduction reaction s (1400 ^{0}C – 1500 ^{0}C) then Pyrolysis (300 ^{0}C – 500 ^{0}C) of biomass into energy. In India 95% of ceramic industries are using gasification technology especially Indian tiles and are saving millions of tonnes of imported oils.

Gasification technologies rely under four key engineering factors:

1. Gasification reactor atmosphere (level of oxygen or air content).
2. Reactor design.
3. Internal and external heating.
4. Operating temperature.

Typical raw materials: Coal, petroleum-based materials, and organic materials.

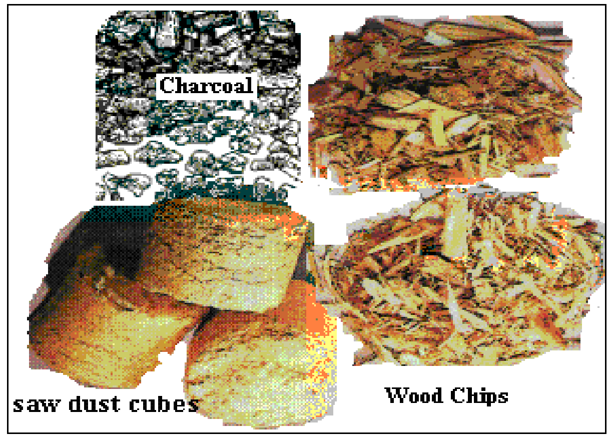
The feedstock is prepared and fed, in either dry or slurred form, into a sealed reactor chamber called a gasifier and feedstock is subjected to high heat, pressure, and either an oxygen-rich or oxygen-starved environment within the gasifier. Indian Institute of Science Bangalore has developed a CGPL (combustion gasification propulsion lab) converting biomass into Pyrogas from two decades. Gasification technology involves:-

- Gobar gas Production
- Biogas
- Synthesis gas

Products of gasification: The different products produced in gasification technology are:-

* Hydrocarbon gases (also called syngas).
* Hydrocarbon liquids (oils).
* Char (carbon black and ash).

Syngas is primarily carbon monoxide and hydrogen (more than 85 percent by volume) and smaller quantities of carbon dioxide and methane



Briquetting of coal dust, wood, saw dust, agricultural residues; paddy husk is done to convert them into solid fuel briquettes. In India briquetted fuel plant is installed at Alternate hydro-centre, Rookie based on the principle of pyrolysis- involves heating of raw material in restricted supply of oxygen at 300 ^{0}C. The briquettes formed are smokeless, used in domestic cooking, hotels, kilns / boilers etc and are sold @ 0.60 rupees per kg i.e. cheaper than firewood and coal.

Gobar gas / Biogas

Gobar gas production is an anaerobic process and the main process Fermentation is carried out in an air tight, closed cylindrical concrete tank called a digester

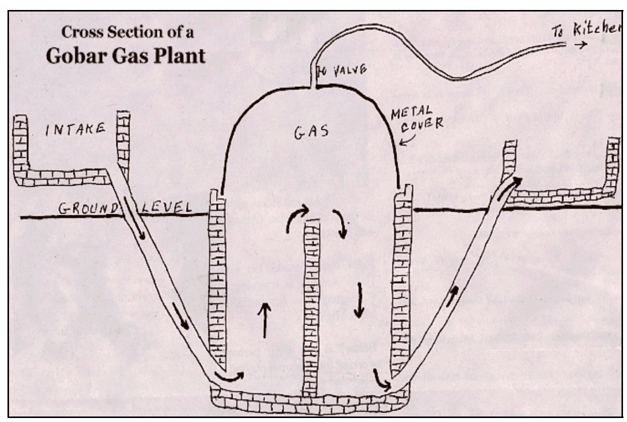
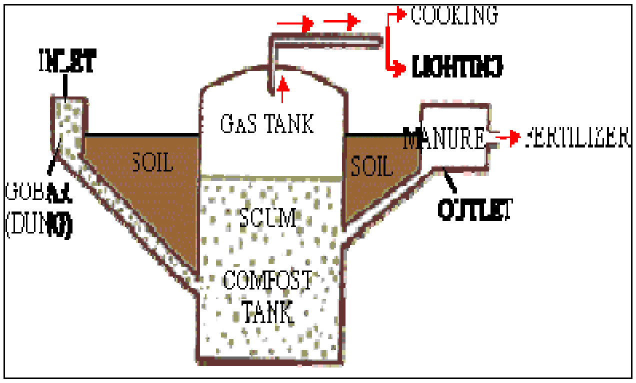


Diagram showing cross section of biogas plant (Cunningham W. P. and Cunningham M. A. 2002)

During biogas production anaerobic digestion is accomplished by a complex community of anaerobic micro-organisms. The Methanogenic (methane forming i.e., *Methanospirillum, Methanospirillum, Methanococcus, Methanobacterium*) bacteria are the terminal group of micro-organisms in a complex community that degrade organic biomass. Methanogens live in closes association with other species of fermentative anaerobic bacteria that breakdown complex organic molecules and synthesize organic acids (acetic acid, lactic acid, butyric acid etc.), alcohols (ethanol, butanol, propanol etc.) and gaseous by-products. These bacteria are referred to as acidogenic bacteria (acid-formers i.e., *Desulfovibrio, Peptococcus, Staphylococcus*). Acidogenic bacteria within genus *Clostridium* play a key role in anaerobic degradation of carbohydrates, and the primary gas by-products they synthesize are hydrogen and carbon dioxide. The organic acids and hydrogen produced by the acidogenic bacteria are in turn, typically metabolized by the methanogens for METHANE production (Wollin and Miller, 1987; Leschine, 1995; Levin *et al*., 2007) [18, 12, 13].



- India already has around 5000 BIOGAS plants and 30 million rural households in China have BIOGAS digesters.
- In 2007, 12000 vehicles were being fueled with upgraded biogas worldwide mostly in Europe (www.newscientist.com/article/mg).

Biogas-Feasibility in Kashmir valley

The biogas technology in Kashmir valley has a tremendous scope to serve as a low cost and renewable source of energy in the region. This technology has been modified and developed for the temperate climate by the SKUAST-K, Srinagar under the financial support by the dept. Of Science and Technology, Govt. of India to improve the socio-economic conditions of the people residing in these areas to a great extent. Biogas is clean and efficient fuel and saves consumption of LPG, kerosene, diesel, petrol, electricity, charcoal and wood. It also eliminates the practice in indiscriminate of trees / soil erosion. An estimate shows availability of 87.06 lakh livestock in Jammu And Kashmir State which reflect the vast potential for biogas generation. If 60% of the livestock @ 5kg dung/livestock/day is utilized for this purpose about 3.26 lakh family size biogas plants of size 2-3 m^3 could be run in the state. Consequently, the biogas generated will suffice the needs of more than 42.57 lakh persons. Energy for cooking alone contributes fifty percent of the total energy budget of the state. The energy production will also save more than 1087.23 million tonnes of fuel wood and also huge amount of biogas digested manure will be available for use in the crops. The use of biogas technology in temperate regions is totally different from that of plains. The low temperature has deleterious effect on methanogenesis and can cause decreased gas yields and digester failure, when digester are not properly designed. The maximum gas yield is obtained when the temperature is between 30 – 35 ^{0}C. Although a lot of research work is being carried out in plain regions of the country but not due attention has given to the temperate regions, especially for temperate region of J and K state.

Biogas Technology developed by SKUAST-K

Keeping in view the above facts the project on “Design of suitable biogas plant for production of methane gas under temperate condition” by the Department of Science and Technology, Govt. of India is governed by the University (SKUAST-K) to design a suitable biogas plant for round the year production of biogas under temperate climatic conditions. Based on the preliminary results the Floating drum type biogas plant with polyhouse and giving additional heat was found successful for producing biogas round the year at the temperature of below -6.0 ^{0}C. The technology is being transferred to the rural peoples of the region through field demonstrations, training programmes and installation of plant at farmer’s field.
(http://www.greaterkashmir.com/)

Table: Showing the typical composition of biogas

Compound	% age
Methane	**50-75**
Carbon dioxide	25-50
Nitrogen	0-10
Hydrogen	0-1
Hydrogen sulphide	0-3

Environmental Benefits of Gobar gas

- Reduction of waste
- Extremely low emission of greenhouse gases compared to fossil fuels.
- Saving time of collecting firewood.
- Protecting forests.
- Saving money.
- Improving hygienic conditions.
- Producing higher quality fertilizer.
- Reducing air and water pollution

Biomass-Source of Energy

The material of plants and animals is called biomass. Biomass is a stored form of solar energy. Biomass provides a clean, renewable energy source that could dramatically improve our environment, economy and energy security (Dembris, 2004) [5]. Biomass energy system offers an opportunity for sustainable, self-reliant and equitable development. Biomass can be burned to produce heat and can be changed into gas like fuels such as methane. Biomass can also be converted into electricity (Woods, 2000, Fukuda, 2003, Bala, 2006) [19, 7, 1]. Biomass can also be converted into liquid fuels called biofuels such as ethanol, methanol, biodiesel and additives of reformulated gasoline. Since biomass can be converted directly into liquid fuel, it could someday supply much of our transportation fuel needs for cars, trucks, buses, airplanes and trains.

- Biomass already supplies 14% of the world’s primary energy consumption. On average, biomass produces 38% of the primary energy in developing countries.
- USA: 4% of total energy from bio mass, around 9000 MW i.e., equivalent to nuclear power of India.
- INDIA is short of 15,000 MW of energy and it costs about 25,000 crores annually for the government to import oil.
- Bio Mass from cattle manure, agricultural waste, forest residue and municipal waste.
- Anaerobic digestion of livestock wastes to give bio gas
- Fertilizers as by product.
- Average electricity generation of 5.5kWh per cow per day!!

Ethanol

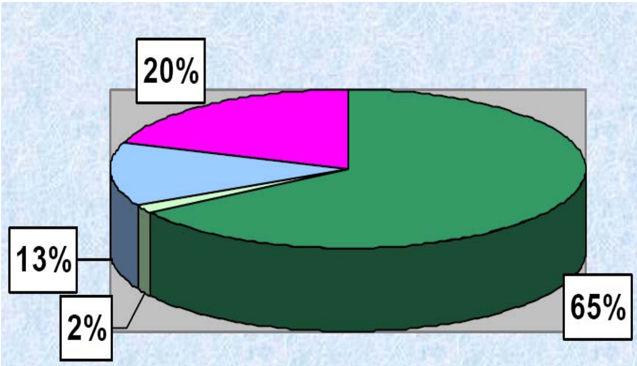
After 25 years, Brazil and North America are still the only two regions that produce large quantities of fuel ethanol, from sugar cane and maize, respectively. Fuel ethanol is currently

made by large scale yeast fermentation of sugars that are extracted or prepared from crops followed by separation of the ethanol by distillation. The first major fuel ethanol programme (ProAlcool) started in Brazil in 1975, followed by programmes in the USA in 1978 and more recently in Canada (table). Although many other countries produce ethanol for fuel and other purposes, major production has only occurred in those countries with especially favourable agricultural conditions.
The different sources of ethanol are as:-

- Sugarcane
- Molasses
- Agricultural waste
- Sorghum
- Grain and Tubers
- Lignocellulosic biomass

Lignocellulosic biomass sometimes called cellulosic biomass is principally composed of the compounds cellulose, hemicelluloses and lignin. Since cellulose and hemicelluloses are principally composed of tightly-bonded sugars, the bonds need to broken before fermentation to ethanol can proceed. Cellulose and hemicelluloses must be broken down into the simple sugars glucose and xylose respectively and this process for cellulosic conversion is known as hydrolysis. Once the cellulose and hemicelluloses have been broken down to simple sugars, fermentation can take place. The yields of ethanol produced from glucose and xylose range from 20-51% and 30-50% respectively. Ethanol production from energy crops is a mature technology. However, ethanol production from Lignocellulosic biomass is not yet at commercial scale, even though many technologies are (Murphy and McCarthy, 2005) [15].

Pie diagram showing world Ethanol Production



(F. O. Litch. World Ethanol and Biofuel Report, 2004; 3: 7)

Table: Showing major fuel ethanol producers

Country	Crop
Brazil (ProAlcool)	Sugarcane & molasses
USA	Maize (95%), some wheat & Barley
Canada	Maize plus 15% wheat

(http://www.distill.com/berg/)

The world scenario of Ethanol
Brazil

- World leader in production and export of ethanol.
- Ethanol produced per day equivalent to 200,000 barrels of gasoline.

24% blend ethanol mandatory.

USA

- Ethanol : a big boost to economy
- E85 sells cheaper than gasoline
- Currently production aimed at 4.5 Billion gallons/yr
- MTBE phased out in many states
- Soya bean main source of biodiesel

India

- ➢ Sources of ethanol
- Sugarcane
- Molasses
- Agricultural waste
- ➢ Annual production capacity of ethanol in India is 1.5 Billion liters

Table: Showing Ethanol Production in India and different routes of production

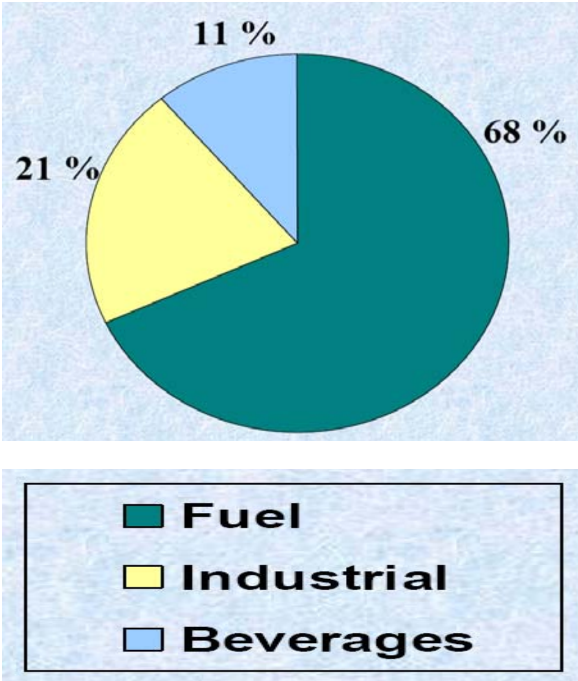
Year	Sugar (lakh tonnes)	Molasses (lakh tonnes)	Alcohol (lakh litres)
2000-01	185.1	78.2	14627
2001-02	185	80.7	15085
2002-03	201	88.7	16593
2003-04	145	59	11033
2004-05	125	50.9	9511
2005-06	160	65	12155
2006-07	185	75.2	14054
2007-08	205	83	15573

(Kumar, 2008) [10]

Routes for Ethanol Production

	Feedstocks		Process
►	Sugarcane/Beet molasses & juice	➲	Fermentation
►	Grain and Tubers (other starchy sources)	➲	Enzymatic saccharification & Acidic Hydrolysis
►	Lignocellulosic Biomass	➲	Acidic Hydrolysis & enzymatic fermentation

Ethanol Application worldwide



(IEA report, 2001)

Biodiesel

Bio-diesel is a renewable and environmentally friendly fuel, which is produced from vegetable oil or animal fat through a chemical process, which has almost no sulphur, no aromatics and has about 10% built in oxygen. It is fatty acid ethyl or methyl ester. Biodiesel can be blended in any ratio with petroleum diesel fuels. It can be stored just like the petroleum diesel fuel and hence does not require separate infrastructure. Blending of biodiesel with diesel would result in the reduction of unburnt hydrocarbon, carbon monoxide and particulate matters in auto emissions and will be in line with the objectives of the Auto fuel policy of the government of India.

- Oil import constitutes a major part of our trade deficit and has an enormous impact on our economy and creation of new jobs
- We spent annually more than 150,000 crores on import of petroleum
- Some day we may be faced with an oil crisis that is not temporary; today oil field discovery and production is on the decline.
- Developing a strong market for bio diesel would have tremendous economic benefits
- Investments in biodiesel technology may ensure that we have transportation fuel options and we will not be so vulnerable.

Biodiesel is monoalkyl ester of long chain fatty acids produced from the Trans-esterification reaction of vegetable oil with alcohol in the presence of catalyst & can be used as fuel.

(Chisti, Y. 2007) [3]

Plant sources of Biodiesel

Biodiesel can be produced from oils both edible and non-edible. India cannot afford to use edible oils for biodiesel as the country is already in short supply and productions of edible oils. The sources of non-edible oilseeds include tree borne oilseeds like Jatropha, Karanja, Jojoba, Neem, Mahua etc. India currently imports about 70% of its petroleum need every year. The demand target may be 120.4 mt for 2006-2007. Our domestic production of crude oil and natural gas will remain around 33.97 mt during 2006-07. The huge gap between demand and supply of 86.43 mt may be met only by import or by producing biofuel. The possible niches for growing of biofuel plants are wastelands in rain fed areas on which crop cultivation is not profitable or not possible. The committee constituted by Planning Commission, Govt. of India (2003) has reported that among the TBO's Jatropha followed by Karanji (Pongamia) are the better sources for biodiesel production from vast areas of waste, degraded and unutilized lands in the country. *Jatropha curcas* has the lowest gestation period (2-3years) and higher oil content in seeds (30-40%) than other tree born oilseeds (Mehla, S. K. 2007) [14].

Table: Showing Plant resources: Non edible TBO

Name of the tree	Scientific name	Gestation period (years)	Oil %
Jatropha	*Jatropha curcas*	2 -3	35 – 40
Karanj	*Pongamia pinnata*	5 - 6	25 – 30
Mahua	*Madhuca indica*	8 - 9	18 -22
Neem	*Azadiracta indica*	9 - 10	9 – 12

(Mehla, S. K. 2007) [14]

Information regarding Jatropha

Scientific name : Jatropha curcas
English name : Purging nut
Family : Euphorbiaceae
Average height : 3-4 m
Area under cultivation : wasteland like salty soil, Sandy soils, mountainous land, dry Land and hard land, forest land
Climatic condition : Grows on adverse conditions.

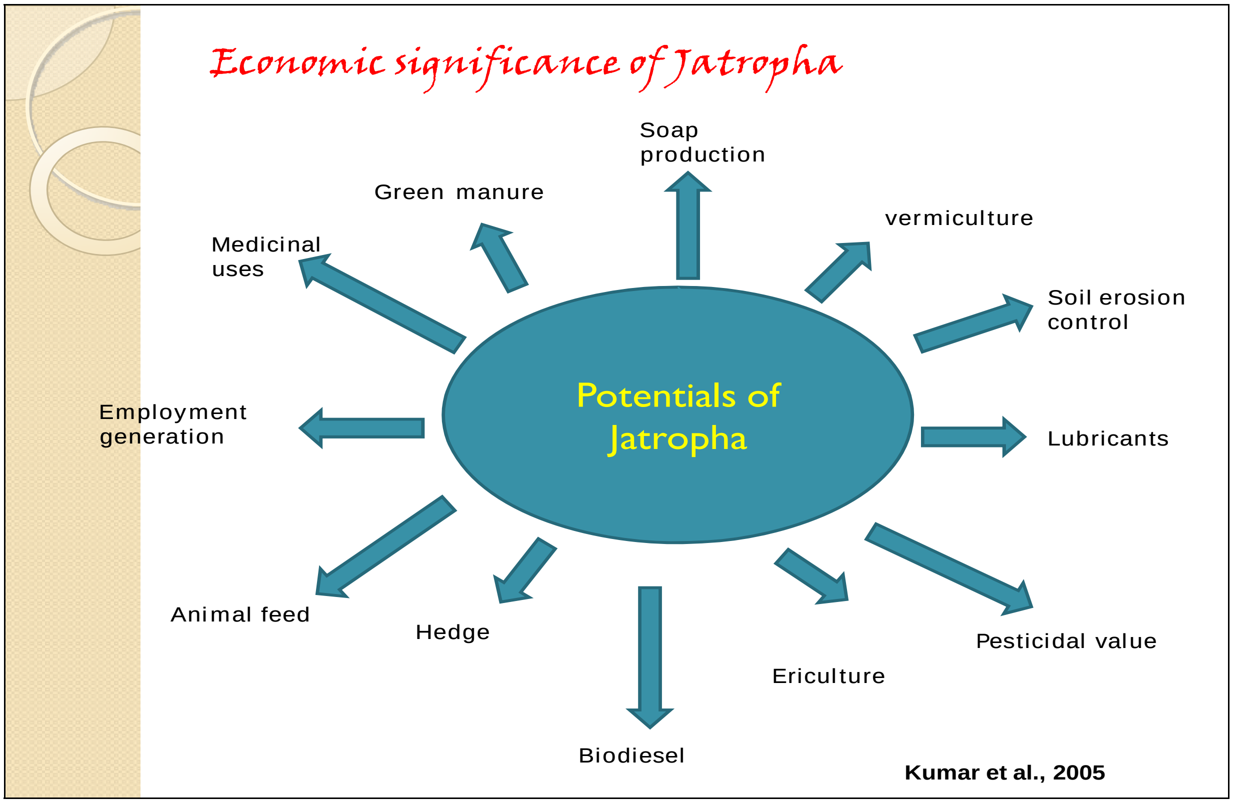
It has been reported that generally one hectare of Jatropha plantation yields 2 tonnes of biodiesel on an average, a total quantity of 2 million of biodiesel will be produced with a value of Rs. 5 billion @ Rs. 25/l. The plantation would absorb 10 million tonnes of carbon dioxide and produce 4 million tonnes of biomanure.

Table: Depicting the land option for Jatropha cultivation in India

Land category	Area (m/ha)
Cultivated lands	13
Strips boundaries	02
Degraded forest	36
Uncultivated degraded land	33
Total	84

[Bhattacharya and Joshi, 2002]

Economic significance of Jatropha



Importance of Bio-diesel

- Eco-Friendly
- Clean burning
- Renewable fuel
- No engine modification
- Increase in engine life
- Biodegradable and non-toxic
- Easy to handle and store

Environmental Benefits from Bio-Diesel

Bio-diesel provides the following environmental benefits:

- Has almost no Sulphur
- In built Oxygen content
- Burns fully
- No Aromatics
- Complete CO_2 cycle
- ➢ Emissions reductions compared to petroleum diesel:
- Carbon monoxide -20%
- Unburned hydrocarbons -30%
- Particulate matter -22%
- Sulphates -20%
- PAH -50%
- Mutagenicity -20%

The first diesel engine was developed by Rudolf Diesel in Germany (1895), it was powered by peanut oil in!

"*The use of vegetable oils for engine fuels may seem to be insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time*".

A test flight has been performed by a Czech jet aircraft completely powered on biodiesel and also the British Royal Train on 15 September 2007 completed its first ever journey run on 100% biodiesel fuel supplied by Green Fuels Ltd.

Biodiesel Demand & Area of Plantation

Year	% age Blend	Biodiesel Requirement (Million Tonnes)	Area of Plantation (Million Hectare)
2011 - 12	5.00	3.35	2.79
2011 - 12	20.00	13.38	11.19
2030		60	
India's Land Area:- 329MH; Wasteland :-60MH			

(Planning Commission Report 2005)

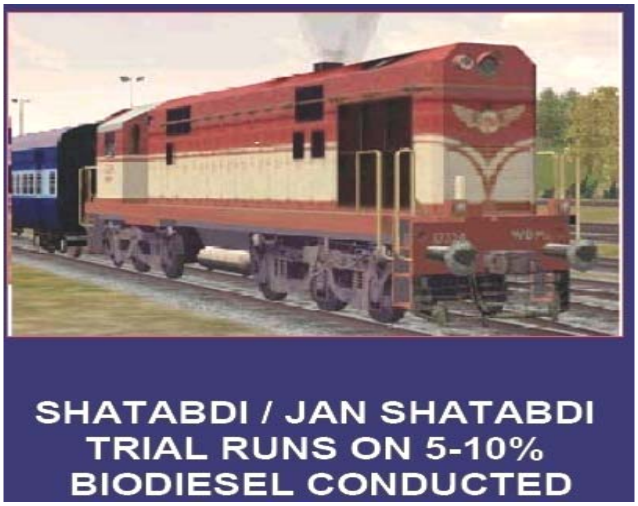
Memorandum of understanding developed between Indian oil corporation (IOC) and Indian railways that resulted Jatropha plantation on 70 Ha of railway land and 1, 10,000 saplings planted in Surendra Nagar Gujrat. Shatabdi & Jan Shatabdi Train Trial Runs conducted earlier and 5 Trains through Lucknow already running from June, 06 on 10% Biodiesel. Reliance has taken up a project of 700million dollars for cultivation of Jatropha in Andhra Pradesh.

It has been found that if one MH of waste land is brought under Jatropha cultivation Can yield one million tons of oil for 66.9 MMT diesel (Projected 2011-12) and also it has been found that 13 MMT bio diesel are required for 20% blending for that 11 MH land are required that will generate 11 million jobs

In India,

5 large plants set up with a capacity of *300,000 liters per day*,
4 medium size plants with a capacity of *30,000 liters per day*,
and a number of small plants with a capacity of *1,000 to 3,000 liters per day*.

Practically all plants are running at very low capacities, or closed due to lack of oil.



(NNFCC, 2011)

Can Biodiesel from *Jatropha* work in India?

India needs 200 Billion gallons of biodiesel per anum to replace all the transportation fuels used To fulfill the above biodiesel demand we require 384 Mh of land for Jatropha cultivation which is a big constraint because India with just 2.4% (328.5 Mh of land) of global area and supports more than 17% of the human population and 18% of the cattle population. So, where do we find the oil for biodiesel? A sustainable source of oil is to be found before we can think of biodiesel.

Comparison of some sources of biodiesel

CROP	OIL YIELD (L/ha)
Corn	172
Soybean	446
Canola	1190
Jatropha	1892
Oil Palm	5950
Coconut	2689
MICROALGAE-A (70% Oil)	1,36,900
MICROALGAE-B (50% Oil)	58,700

(Chisti, Y. 2007) [3]

Microalgae can provide several different types of renewable biofuels. These include methane produced by anaerobic digestion of the algal biomass, biodiesel derived from micro algal oil. The idea of using microalgae as a source of fuel is not new but it is now being taken seriously because of the escalating price of petroleum and more significantly, the emerging concern about global warming that is associated with burning of the fossil fuels. (Chisti 2007). The algae that are used in biodiesel production are usually aquatic unicellular green algae. These types of algae are photosynthetic eukaryotic characterized by high growth rates and high population densities. Under good conditions, green algae can double its biomass in less than 24 hours. Additionally, green algae can have huge lipid content, frequently over 50%. This high yielding high density biomass is ideal for intensive agriculture and may be an excellent source for biodiesel production. In India only 5.4Mh area of algae ponds are required to replace all the petroleum transportation fuels.

Table: Showing comparison of oil content found in green algae

Species	Oil content %
Chlorella species	28-32
Nitzschia species	45-47
Nannochloropsis species	31-68
Schizochytrium species	50-77
Isochrysis species	25-75
Botryococcus species	25-75
Spirogyra species	8.09
Oedogonium species	12.00

(Chisti, Y. 2007) [3]

Conclusion

Blending of biodiesel in diesel offers great opportunities for environment protection and rural economy development. There is need to promote the species on marginal or wasteland only and establish processing units of low to medium size, preferably run by local entrepreneurs. Genetic improvement of particular species should be taken as future aspects i.e., to increase oil content in the plants and to decrease its gestation period. Strict environmental regulations and emission norms have led to improvement in fuel quality and introduction of clean fuels like biodiesel. Identification and mass production of high yielding biofuel plants like lower plants (microalgae).

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