

Biofuel Production in India: Potential, Prospectus and Technology

Prof. Vijaykumar G Tile¹, Shivaraj.K², Raju³, Shivaprakash.B⁴

Assistant Professor, Department of Mechanical Engineering, Malnad Engineering College, Hassan, India¹

U.G. Students, Department of Mechanical Engineering, Malnad Engineering College, Hassan, India^{2,3,4}

ABSTRACT: New generation energy sources is very much essential in Indian and global context. The available renewable sources have to be optimized to give maximum bio-fuel returns. The selective techniques have been imprisoned on the research institutes and University laboratories. The major sources includes Algae, Jatropha oil and vegetable oils, cellulosic materials, corn and sugarcane etc. have been under surveillance since late 1990s. Major drawback so far for renewable energy sources are continuous flow of energy of bio-fuel from a single one. Overestimation of potential of Jatropha oil, as a potent source has been identified and slowly rejected by growers and the planners. Algae, one of the most effective sources of biodiesel production technique and availability of water sources has been under scanner. The conversion of vegetable oil and food grain sources for biodiesel got thumb down indicator from many. The new addition of cellulosic bio-fuel as a second generation bio-fuel has abundant availability of raw material. But, it required a lot of research hours to confirm the best suitable technique and the best source for economically viable production system. Under the mentioned constraints, lays the hope and assurance for finding best source and technique to produce bio-fuel for the use of masses. As, the conventional sources of energy drying up at faster rate, the alternate sources be explored, examined and implemented in no time.

KEYWORDS: Biofuel; India, Algae; Cellulosic Ethanol; Jatropha.

I. INTRODUCTION

Energy is the chief mover of economic growth, and plays a vital role in sustaining the modern economy and society. Our future economic growth considerably depends on the long-term accessibility of energy from the sources that are easily available, safe and affordable. The global economic growth has seen a dramatic increase in the energy demand of the world. Energy consumption is expected to increase by 84 percent by 2035 in most of the developing countries. India faces a dreadful challenge in meeting its energy needs and in providing sufficient energy of preferred quality in various forms in a sustainable manner and at competitive prices. If India has to eradicate poverty and meet its human development goals, then it has to sustain an 8% to 10% economic growth rate, over the next 25 years. For delivering a sustained growth rate of 8%, India needs to increase its primary energy supply by 3 to 4 times. New sources of energy like biofuels may play a significant role in meeting the energy demands. Biodiesel benefits include bio-degradable, non-toxic, free from sulphur (< 0.001 %) and 60% less net carbon dioxide emissions. In addition, it has high flash point (greater than 160 OC) which helps biodiesel by transportation and storage. The important quality that biodiesel possesses is that it decomposes more easily when they expose to environment and most importantly they can be produced easily compared to petrol and diesel. Another advantage of using biodiesel is that it eliminates the compound such as polycyclic aromatic hydrocarbons (PAH) and nitrated PAH that causes cancer in humans. The lubrication property of biodiesel dominates more when compared to the diesel fuel and increases the engine life. Biodiesel causes less emission of carbon dioxide (CO₂), hydrocarbon (HC) and particulate matter (PM), which are the dominant factors while compared with diesel. A long run endurance test has been conducted by researchers around the world and proved that it can be easily used in compression ignition engines without any modification. The only drawback in the case of biodiesel such as NO_x emission is to be reduced. Many researches are in process for reducing the NO_x during and after the combustion process.

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II. HISTORY OF BIOFUEL

Biofuels in the solid form as been use ever since man discovered fire. Wood was the first form of biofuel that was used even by ancient people for cooking and heating. With the discovery of electricity, man discovered another way of utilizing the biofuel. Biofuel had been used since a very long time for production of electricity. This form of fuel was discovered even before the discovery of the fossil fuels, but with the exploration of the fossil fuel like gas, coal, and oil the production and use of biofuel suffered a severe impact. With the advantages placed by the fossil fuels they gained a lot of popularity especially in the developed countries. Liquid biofuel have been used in the automotive industry since its inception.

One of the first inventors to convince the people of the use of ethanol was a German named Nikolaus August Otto. Rudolf Diesel is the German inventor of the diesel engine. He designed his diesel engine to run in peanut oil and later Henry Ford designed the Model T car which was produced from 1903 to 1926. This car was completely designed to use hemp derived biofuel as fuel. However, with the exploration of huge supplies of crude oil some of the parts of Texas and Pennsylvania petroleum became very cheap and thus lead to the reduction of the use of biofuels. Most of the vehicles like trucks and cars began using this form of fuel which was much cheaper and efficient.

In the period of World War II, the high demand of biofuels was due to the increased use as an alternative for imported fuel. In this period, Germany was one of the countries that underwent a serious shortage of fuel. It was during this period that various other inventions took place like the use of gasoline along with alcohol that was derived from potatoes. Britain was the second country which came up with the concept of grain alcohol mixed with petrol. The wars frames were the periods when the various major technological changes took place but, during the period of peace, cheap oil from the gulf countries as well as the Middle East again eased off the pressure.

With the increased supply the geopolitical and economic interest in biofuel faded away. A serious fuel crisis again hit the various countries during the period of 1973 and 1979, because of the geopolitical conflict. Thus (OPEC), organization of the petroleum Exporting countries made a heavy cut in exports especially to the non OPEC nations. The constant shortage of fuel attracted the attention of the various academics and governments to the issues of energy crisis and the use of biofuels. The twentieth century came with the attention of the people towards the use of biofuels. Some of the main reasons for the people shifting their interest to biofuels were the rising prices of oil, emission of the greenhouse gases and interest like rural development.

III. PROCESS OF PRODUCTION BIODIESEL

Biodiesel is commonly produced by the transesterification of the vegetable oil or animal fat feedstock.

Stage of Biodiesel production: Single Phase

- Filtration of the oil to remove the suspended impurities.
- Heating the oil to about 650 c under controlled agitation with a stirrer using 200-350 RPM.
- Based on the quantum of free fatty acid available in the oil decide, the amount of Methyl alcohol and alkali (NaOH & KOH) to be added to the oil.
- Add the Methoxide and continue the heating maintaining the temperature between 650c to 700c agitating using a stirrer at 500 rpm.
- Give a process time of 45 to 60 minutes. Collect a small quantity of the mixture in a small beaker and check up the completion of the reaction. Clear separation of two layers, i.e. Biodiesel at the top and Glycerine etc. at the bottom, indicating the completion of the process.
- Transfer the above mixture in to a settling vessel and allow to cool and settle for 2 to 3 hours. The biodiesel on the top and the Glycerine, un-reacted oil and other impurities at the bottom.
- Collect the Glycerine portion by decanting.
- The top portion which is Bio-Diesel will be alkaline, wash with distilled or de-mineralized water number of times to get the Bio-diesel to neutral stage, i.e., about 7pH.
- The washing will be containing soap solution which can be used for cleaning purpose.
- The Bio-diesel which contains some quantity of water can be dried in an air-oven at 1100c-1200c.

Two phase process

- Take known quantity of oil (Previously filtered up to 53 microns thickness sieve).
- Add 1.5 ml of concentrated sulphuric acid and 80ml of Methanol per litre of oil.
- Heat and stir at 500/1400 rpm for 2 hours.
- Settle over night.

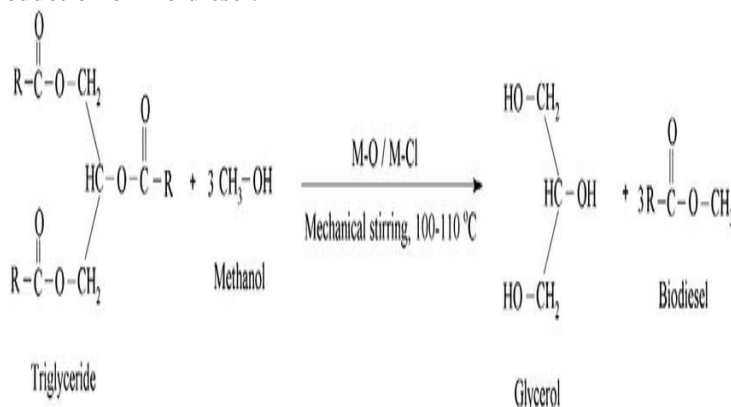
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- Prepare sodium methoxide or Potassium solution ie. 8- 12 gmsNaOH or 12 to 17 gms, KOH in 120-130 ml methanol per litre of oil.
- Add 50% volume of methoxide solution heat the content to 600c for neutralization. • Add remaining 50% volume of Methoxide at about 600 c stir at about 600 c stir at 500 rpm and 1 hour process time.
- Phase separation is noticed and transfers the content to settling vessel.
- Settle for three hours.
- Drain the bottom layer containing Glycerine etc.
- Top layer is bio-diesel and is alkaline in nature. Wash it with water, using air-pump, bubbling slowly.
- After 4 to 5 washes Bio-diesel will became neutral.
- Measure the quantity of Biodiesel and arrive the yield. In case of **pungam oil** yield is around 85%.
- Heat the Bio-diesel at 1100 c for removal of water if any present. After heating, Bio-diesel is clear. Settle for some time and use.

Reaction showing the production of Bio-diesel:



Where R is long hydrocarbon chains, sometimes called fatty acid chains.

IV. BIOFUEL RESOURCE IN INDIA

Biofuel potential Energy consumption is increasing at 6.5 per cent per annum, while reserves of petroleum are decreasing day by day. India's share of crude oil production is about 1 per cent of global crude oil production, whereas consumption amounts to 3.1 per cent of global consumption. A no. of private and Government organizations are involved in production and distribution biofuel in India. The leaders in biofuel processing in India are, D1 Oil Plc, Reliance Industries Ltd, Godrej Agrovet, Emami Group, Aatmiya Biofuels Pvt Ltd., Gujarat Oelo Chem Limited (GOCL), Jain Irrigation System Ltd., Nova Bio Fuels Pvt. Ltd., Sagar Jatropa Oil Extractions Private Limited etc.

It is wise to consider the oil yield potential of different edible and non-edible crops (Table 1), before selecting the crop as suitable source of biodiesel production. Considering the food grain scarcity in developing countries like India, edible major crops may be spared as a potential source for bio-diesel production. Typical feed stocks for biodiesel production are soybean, canola/rapeseed, sun flower, cottonseed, palm seed and palm kernel, corn and mustard seed oil. Pork, beef and poultry fat and grease also can be converted to biodiesel. Palm oil and animal fat may have a high free fatty acid content, which causes soap formation that has adverse effects on downstream processing and leads to yield reduction. The detailed agricultural biofuel potential of India is estimated.

The blending mandate of 5% ethanol with gasoline in nine states of India in 2003 was enhanced to include 20 states in 2006. In 2010, the National Policy on Biofuels approved a target 20% blending with biofuels by this year.

Algae have been in contention as one of the major source of biodiesel in near future. Cultivation of algae does not necessarily need prime agricultural land and can be grown under desert like conditions using brackish and saline waters that are unfit for terrestrial crops the water used for algal cultivation does not compete for agriculturally important activities . Various studies in design of Raceway ponds with varying design parameters like water depth, stirrer design,

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velocity of circulation, sparging of gas and gas compositions, and rate and type of algal harvesting with recirculation of media and partial replenishment of media/media components, have been undertaken.

Cost effectiveness and better resilience have been the key characteristics of open pond based algal systems compared to photo bioreactors. The open ponds are usually reported to be dominated by two to six species of microalgae with a range of evolutionary advantages; rapid growth, resistance to predators, tolerance to high levels of dissolved oxygen. Open pond system is 10 times less expensive compared to photo bioreactors. Wet-land rice cultivation field may be used for micro algae growth as an intercrop with rice without affecting rice yield.

Second generation or cellulosic ethanol is produced from agricultural residues containing cellulosic biomass— such as the stalks, leaves, bagasse, and husks of rice, wheat, wood chips, sawdust or energy crops. India has great stock of biomass for cellulosic biofuel production. Praj Industries has finally started construction of second generation cellulose based bioethanol plant in India. At \$25 million plant, cellulosic ethanol will be made from agro-waste unlike first generation fuel that is made from food crops.

V. GOVERNMENT INITIATIVES

Government has set up a target of 20% blending by 2017. Apex financial institutions like the National Bank for Agriculture and Rural Development (NABARD), Indian Renewable Energy Development Agency (IREDA) and Small Industries Development Bank of India (SIDBI) have refinancing provisions to set up biodiesel plantations, oil expelling/ extraction units, and infrastructure for storage and distribution. The Bio-Diesel Association of India (BDAI), is a non-profit national association representing the biofuels sector more specifically biodiesel industry as the coordinating body for marketing, research and development in India, encourage biofuels specially biodiesel and assure sustainable agricultural growth, rural development, energy security and equal opportunity for the masses with overall environmental protection. India's biofuel policy exempts the biofuel sector from central taxes and duties. While biodiesel is exempt from excise duty, bioethanol enjoys a concessional excise duty of 16%. Customs and excise duty concessions are also provided on plant and machinery for the production of biodiesel and bioethanol. These policies promote the biofuel sector. Though the policy mentions exemption of central taxes and duties on biofuels, sales tax, license fee, permit fee and import taxes still exist, hindering the growth and development of the industry.

Sl. No.	Oil yield potential ('000 l/ha)	Crop type
1	47.5-142.5	Micro algae
2	6.0	Oil palm
3	2.0	Jatropha
4	1.25	Canola
5	1.2	Rapeseed
6	1.0	Sunflower
7	0.2	Corn

Table 1:oil yield potential of different crops.

VI. SOURCES FOR BIODIESEL PRODUCTION

In recent times biodiesel has been produced from sources like vegetable oils, animal fats, soap stock and also recycled frying oils. In order to know which vegetable oil is best suited for the production of biodiesel, certain factors like geography, climate, and economics must be considered. Vegetable oils are considered as the renewable forms of fuel and they are more attractive in environmental benefits as they are made from renewable resources. Vegetable oil potentially forms the unlimited source of energy; with an energy content equivalent to that of diesel fuel. Direct use of vegetable oil in diesel engines gives rise to many problems such as jamming and gumming of filters, lines and injectors; engine knocking; starting problem during cold weather; coking of injectors on piston and head of engine; extreme engine Wear; carbon deposition on piston and head of engine [8]. Vegetable oils are of high viscosity and in

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order to reduce their viscosity and to overcome their problems to enable their use in many diesel engines, a process called transesterification must be carried out. The product so formed after transesterification is called as biodiesel. Biodiesel has relatively higher heating values. Biodiesel is 100% pure and hence it is referred as “neat fuel” or “B100”. The high heating values (HHV’s) of biodiesel ranges from 39 to 41MJ/kg. Biodiesel can be utilized by blending with petrol diesel and those blends are referred as BXX where XX represents the amount of biodiesel in the blend. Pure biodiesel can be denoted as B100.

Algae biodiesel:

Algae are aquatic oxygenic prototrophes. Microalgae are considered to be attractive source for energy for various reasons, Such as: The biomass productivities (dry weight per unit time per unit area) of some microalgae are much higher than those of higher plants. Some microalgae grow fast. The lipid and starch contents of some microalgae are high (over 30% w/w). Microalgae are relatively easy to cultivate. Algae can be cultivated on non arable land or in water. Thus, the energy production by algae does not compete for land with food production. However, the cost of biodiesel production from algae is very high (Figure 3). Cultivating algae under rural conditions requires novel multi-tier, multi-cyclic approaches of sharing land area without causing threats to food and water security as well as demand for additional fertilizer resources by adopting multi-tier cropping (algae-paddy) in decentralized open pond systems.

Cellulosic ethanol—Biofuel:

Cellulose is a polymer of sugar, polymers are large molecules made up of simpler molecules bound together much like links in a chain. Common, everyday biological polymers include cellulose (in paper, cotton, and wood) and starch (in food). Cellulose is a polymer of glucose, a simple sugar that is easily consumed by yeast to produce ethanol Figure 1. Cellulose is produced by every living being. The three major challenges in cellulose ethanol production are; Firstly, cellulosic feed stocks must be available in large volumes when needed by refineries. Second, the cost of converting cellulose to ethanol or other biofuels must be reduced to a level to make it competitive with gasoline and corn-starch ethanol. Third, the marketing, distribution, and vehicle infrastructure must absorb the increasing volumes of renewable fuel, including cellulosic fuel mandated by RFS.

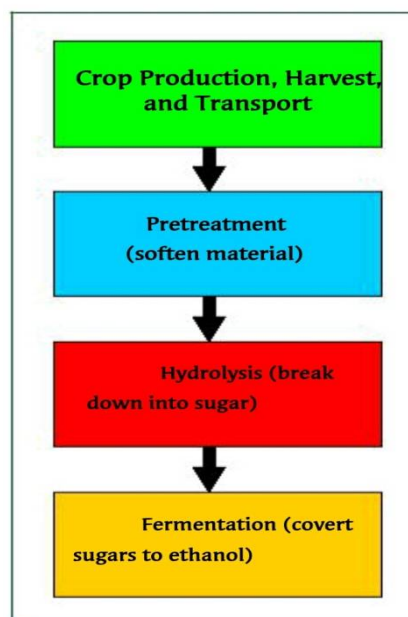


Figure 1. Major Challenges in Producing Cellulosic Ethanol

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VII. JATROPHA BIODIESEL IN INDIA

Bio fuel development in India centres mainly around the cultivation and processing of jatropha plant seeds which are very rich in oil (40%).the drivers for this are historic, functional, economic, environmental, moral, and political. Jatropha has been used in India for several decades as biodiesel for the diesel fuel requirements of remote rural and forest communities ;jatropha oil can be used directly after extraction (i.e., without refining) in diesel generators and engines. Jatropha has the potential to provide economic benefits at the local level since under suitable management it has the potential to grow in dry marginal non-agricultural lands, thereby allowing villagers and farmers to leverage non farm land for income generation. As well, increased jatropha oil production delivers economic benefits to India on the macroeconomic or national level.

It is a non edible oil-bearing plant, widely spread in the tropical regions of the world. Jatropha curcas L (JCL) is having equivalent properties to biodiesel production due to its calorific value and cetane number. As a result JCL is having concern to produce biodiesel. A study made by Azam et al., says that palm oil biodiesel when blended with Jatropha biodiesel at about 20-40% will improve oxidation stability and low temperature property. Hence Jatropha biodiesel has good low temperature property and palm biodiesel has good oxidative stability and also it was initiated that antioxidant dosage could be reduced by 80-90%. According to Sarin et al. jatropha seed is capable of producing a significant amount of oil for biodiesel production. This is a non-edible oil-bearing plant widespread in arid, semi-arid and tropical regions of the world. Jatropha is a drought resistant perennial tree that grows in marginal lands and can live over 50 years.

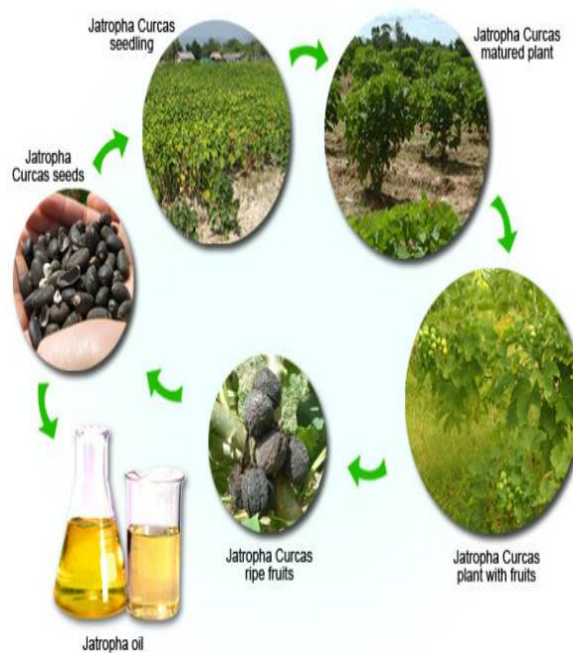


Figure: Jatropha life cycle

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Properties of biodiesel:

S. No	Biodiesel properties	Measured values	Units
1	Density at 20°C	950	kg/m ³
2	Kinematic viscosity 40°C	38.7	mm ² /s
3	Flash point (°C)	150	°C
4	Acid value	12.6	mgKOH/g
5	Saponification value mgKOH/g	180	mgKOH/g
6	Moisture content	0.019	(%)w/w
7	Ash content	0.04	(%)w/w
8	Iodine value	90.6	I ₂ g/100g
9	Free fatty acidic	5.28	%
10	Melting point	30.2	°C

VIII. CONCLUSION

Fossil fuels are non renewable forms of energy resources and they are depleting day by day so the production of biofuels such as biodiesel is increasing rapidly. Biofuels like biodiesel are renewable, eco-friendly and non-toxic energy resources. Biodiesel is similar to petroleum diesel in its properties but biodiesel emits very less amount of CO₂, sulphur and particulates compared to petroleum diesel. It can be produced by a simple transesterification process using acid or base catalyst or enzymes as catalyst. Enzymatic transesterification process using lipases gave high yield of biodiesel but because of the high cost of lipases, enzymatic transesterification is not much followed. But catalytic transesterification has several problems like removal of catalyst and product purification etc., so non catalytic transesterification such as BIOX process, supercritical process have become the most preferable method for biodiesel production. Recent studies show that microalgae are the best and an ever green source for biodiesel production as microalgae has many advantages over other conventional sources.

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