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# Biofuels and Recent Development in India: A Review

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## ABSTRACT

The crude oil price has been fluctuating in the world market. Such fluctuations are straining various economies the world over, particularly those of the developing countries.Government has prepared a road map to reduce the import dependency in Oil & Gas sector by adopting a five pronged strategy which includes, Increasing Domestic Production, Adopting biofuels & Renewables, Energy Efficiency Norms, Improvement in Refinery Processes and Demand Substitution. Over the last decade, Government has undertaken multiple interventions to promote biofuels in the Country through structured programmes like Ethanol Blended Petrol Programme, National Biodiesel Mission, Biodiesel Blending Programme. Biofuels offers great opportunity to increase farmers' income, import reduction, employment generation, waste to wealth creation.

**KEYWORDS:** Biofuels, Ethanol, Biodiesel, India

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## 1. INRODUCTION

Energy is a critical input towards raising the standard of living of citizens. Conventional or fossil fuel resources are limited, non-renewable and polluting. On the other hand, renewable energy resources are indigenous, non-polluting and virtually inexhaustible. The domestic crude oil production[1] meet less than 20% of the demand, while the rest is met from imported crude. This huge gap between demand and supply which is presently met by imports putting heavy burden of foreign exchange[2] on the country. Again the crude oil price has been fluctuating in the world market. Such fluctuations are straining various economies the world over, particularly those of the developing countries. India's energy security will remain vulnerable until alternative fuels to substitute/supplement petro-based fuels are developed based on indigenously produced renewable feedstock.

## 2. HISTORY OF BIOFUELS

In the mid-1800s, ethanol[3] was a major lighting fuel. But during Civil War a liquor tax was placed on ethanol and Ethanol production declined sharply. In early 1900s after the tax was replaced, Henry Ford designed his Model T, a very early automobile, to run on a mixture of gasoline and alcohol. Ford called this mixture the '*fuel of the future'*. Rudolf Diesel invented the diesel engine in 10$^{th}$ August 1893 to be powered by peanut and other vegetable oils. In remembrance of this event August 10 has been declared as International Biodiesel Day. That was before cheaper petroleum-based diesel fuel became widely available. Engine makers then altered Rudolph Diesel's original engine to suit petro-diesel – but running on biofuels is what they were originally designed to do. During World War II when oil and other resources were scarce, Ethanol is once again used to fuel automobiles. In the 1970s, interest in ethanol as a transportation fuel was revived as oil embargoes, rising oil prices, and growing dependence on imported oil increased interest in alternative fuels. Since that time, ethanol use and production has been encouraged by tax benefits and by environmental regulations that require cleaner-burning fuels. Biodiesel works in the engine in the same way as standard diesel, and has added benefits to human health and the environment in that it produces less toxic particulates and greenhouse gas emissions.

## 3. BIOFUELS

'Biofuels'[4] are fuels (such as ethanol and biodiesel) produced from renewable resources and used in place of or in blend with diesel, petrol or other fossil fuels for transport, stationary, portable and other applications. Renewable resources are the biodegradable fraction of products, wastes and residues from agriculture, forestry, tree based oil other non-edible oils and related industries as well as the biodegradable fraction of industrial and municipal wastes.

### *3.1 Ethanol*

Ethanol is an alcohol fuel made from the sugars found in grains such as corn, sorghum, and barley. Other sources of sugars to produce ethanol include Sugar cane, Sugar beets, Potato skins, Rice, Yard clippings, Tree bark, Switchgrass etc. Scientists are working on ways to make ethanol from all parts of plants and trees rather than just grain. Farmers are experimenting with fast-growing woody crops such as small poplar and willow trees and switchgrass to see if they can be used to produce ethanol.

#### 3.1.1 Ethanol Made from Biomass

Ethanol is a renewable biofuel because it is made from biomass. Ethanol is a clear, colourless alcohol made from a variety of biomass materials called feedstocks (the raw materials used to make a product). Fuel ethanol feedstock's include grains and crops with high starch and sugar content such as corn, sorghum, barley, sugar cane, and sugar beets. Ethanol can also be made from grasses, trees, and agricultural and forestry residues such as corn cobs and stocks, rice straw, sawdust, and wood chips. Ethanol is made from these feedstock's in several ways.

#### 3.1.1.1 Fermentation Process[5]

The most common ethanol production processes today use yeast to ferment the starch and sugars in corn, sugar cane, and sugar beets. Sugar cane and sugar beets are the most common feedstock's used to make fuel ethanol. Because alcohol is made by fermenting sugar, sugar crops are the easiest ingredients to convert into alcohol. Brazil, the world's second-largest fuel ethanol producer after the United States, makes most of its fuel ethanol from sugar cane. Most of the cars in Brazil can run on pure ethanol or on a blend of gasoline and ethanol.

#### 3.1.1.2 Cellulosic Ethanol

Ethanol can also be produced by breaking down cellulose in plant fibers. This *cellulosic ethanol*[6] is considered an advanced biofuel and involves a more complicated production process than fermentation. While large potential sources of cellulosic feedstock's exist, commercial production of cellulosic fuel ethanol is relatively small.Trees and grasses require less energy, fertilizers, and water to grow than grains do, and they can also be grown on lands that are not suitable for growing food crops. Scientists have developed fast-growing trees that grow to full size in 10 years. A company in the United States is using the corn cobs and stocks of corn plants to make cellulosic fuel ethanol.

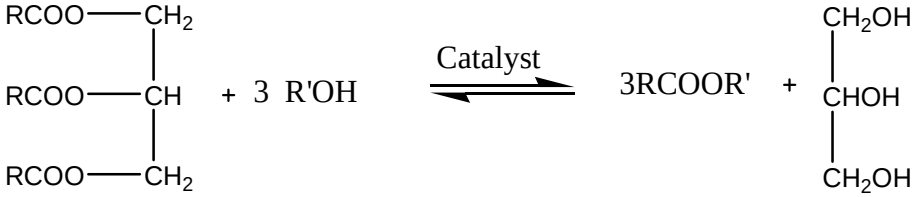
## *3.2 Biodiesel*

Biodiesel[7] is commonly made from vegetable oils such as canola oil, animal fats (tallow) or recycled greases such as used cooking oil. Other feedstock's being developed include algae, pongamia trees and juncea (a species of mustard plant). These renewable feedstock's contain fatty acids which undergo process of condensation called transesterification (which was invented so that diesel engines could use biodiesel again). Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a blend to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Blends vary from as little as 5% (B5) to pure 100% biodiesel, and the most common blends are B5, B20 and B100.

Many studies have shown that the properties of biodiesel are very close to diesel fuel[8,9,10]. Therefore,biodiesel fuel can be used in diesel engines with little or nomodification. Biodiesel has a higher cetane number than diesel fuel, no aromatics, no sulfur, and contains 10-11% oxygen by weight. These characteristics of biodiesel are responsible for a reduction inthe emissions of carbon monoxide (CO), hydrocarbon (HC) and particulate matter (PM) in the exhaust gas compared to diesel fuel[11,12].

### 3.2.1 Biodiesel Production

The preparation[13] of biodiesel is generally carried outusing vegetable oils or animal fats as a starting material. Biodiesel is produced by transesterification of the triglycerides with short chainalcohols in the presence of a suitable catalyst. The reaction is shown in Scheme 1. The



**Scheme 1 Transesterification reaction of triglyceride**

stoichiometry requires 3 mol of alcohol and 1 mol of triglyceride to give 3 mol of fatty acid esters and 1 mol of glycerine. The overall process is a sequence of three consecutive reversible reactions where di-glyceride and mono-glyceride are intermediate products. The transesterification reaction can be catalyzed by both acid and alkaline catalysts, using a homogeneous or heterogeneous catalytic process. The reaction is associated with several other side reactions, which if uncontrolled can severely hamper the product yield and quality.

### *3.3 Advanced Biofuels*

Advanced biofuels produced from lignocellulosic[14] feedstock's (i.e. agricultural andforestry residues, e.g. rice & wheat straw/corn cobs & stover/bagasse, woody biomass), non-food crops (i.e.grasses, algae), or industrial waste and residue streams, having low $CO_2$ emission or high green house gases (GHG) reduction and do not compete with food crops for land use. Fuels such as Second Generation (2G) Ethanol, Drop-in fuels, algae based 3G biofuels, bio-CNG, bio-methanol, Di Methyl Ether (DME) derived from bio-methanol, bio-hydrogen, drop in fuels with MSW as the source / feedstock material will qualify as "Advanced Biofuels"[15]

## 4. INDIA AND BIOFUELS

Over the last decade, Government has undertaken multiple interventions to promote biofuels in the Country through structured programmes like Ethanol Blended Petrol Programme[16], National Biodiesel Mission, Biodiesel Blending Programme. Learning from the past experiences and demand supply status, Government has revamped these programmes by taking steps on pricing, incentives, opening alternate route for ethanol production, sale of biodiesel to bulk and retail customers, focus on R&D etc. These steps have impacted the biofuels programme in the Country positively.

## 5. GOVERNMENT POLICY

India initiated its befoul program me more than a decade ago and launched several policy measures to promote biofuels since then. In 2002, India launched its "Ethanol Blending Program me" and mandated a 5% blending of ethanol (E5) with petrol in nine States and four Union Territories with effect from January 2003[17]. The Planning Commission of India constituted a Committee on Development of Biofuels in July 2002. The report of the Committee, released in

2003, recommended India to progressively move towards higher targets regarding blending of biofuels, including strengthening of the ethanol blending program me.

However, the 5% blending mandate in the case of ethanol could not be met due to shortage of bioethanol supply; in October 2004, the mandate was amended "requiring E5 blends only when adequate ethanol supplies were available"[18]. In 2006, the 5% blending mandate was extended to cover 20 States and 8 Union Territories; again this target could be met due to shortage of bioethanol supply. In September 2008, the Union Cabinet set a target of 5% blending across the country. Although the 5% target could not be realized, the Government set a target of 10% blending in October 2008. The Planning Commission report of 2003 recommended launching of a National Mission on Biodiesel to be based on non-edible oil and identified Jatropha curcas as the most suitable tree-borne oilseed for biodiesel production[19]. One aim of the Mission was to gradually raise the blending target to 20% by the year 2012. The Planning Commission estimated that 11.2 million hectare of land would be required for Jatropha plantation to achieve the 20% target by 2012 and identified 13.4 million hectare of land that could be actually used for plantation. In October 2005 the Ministry of Petroleum and Natural Gas announced a biodiesel purchase policy, which required Oil Marketing Companies to procure biodiesel in the country for blending with diesel with effect from January 2006. In order to strengthen the faltering ethanol and biodiesel blending programs, India's National Biofuel Policy was approved by the Govt. of India in December 2009.

Government has prepared a road map to reduce the import dependency in Oil & Gas sector by adopting a five pronged strategy which includes, Increasing Domestic Production, Adopting biofuels & Renewables, Energy EfficiencyNorms, Improvement in Refinery Processes and Demand Substitution. This envisages a strategic role for biofuels in the Indian Energy basket. In December 2009, the Union government launched the National Biodiesel Mission (NBM)[20] identifying *Jatropha*as the most suitable tree-borne oilseed for biodiesel production to help achieve a proposed biodiesel blend of 20 per cent with conventional diesel by 2017. Biodiesel procurement started in 2014 and a pilot programme was started in August 2015. It has been extended to six states. However, due to an acute shortage of *Jatropha* seeds, the government's ambitious plan did not materialise. Moreover, several existing biodiesel plants shifted operations to adopt multiple feedstock technology. For instance, they use used cooking oils, animal fats and imported crude vegetable oils to produce biodiesel while private producers

are encouraged to sell more biodiesel directly to end-users provided they meet the prescribe Bureau of Indian Standards (BIS) norms. According to the Union Ministry of Petroleum and Natural Gas (MoP&NG), as on July 1, 2016, 1.32 crore litres of biodiesel has been procured by public sector Oil Manufacturing Companies (OMCs). The biodiesel production from multiple feedstocks reported during the years 2014, 2015 and 2016 was 130, 135 and 140 million litres respectively, and was estimated to go upwards of 150 million litres in 2017. It would add another 10 million litres through 2018. In June 2018 that the government has approved the National Biofuels Policy 2018[21].

## 6. IMPLIMENTATION AND FUTURE PLANNING

For research and development and technology government encouraging participation of industry. Few areas have been identified[21] for R&D work which include biofuel feedstock production, advanced conversion technologies from identified feedstock, technologies for end use applications including modifications for befouls and utilization of bi-products of biofuels. The policy encourages setting up of State Level Biofuel Development Boards in line with the broad contours and provisions of this National Policy on Biofuels. Rajasthan becomes 1st Indian state to implement befoul policy[22]. Five Boards are functional in the States of Chhattisgarh, Uttar Pradesh, Karnataka, Rajasthan and Uttarakhand. States will also be encouraged for granting single window clearances in setting up biofuel plants.

Favourable government policies as well as the vigorous participation of local communities and private entrepreneurs can sustain the programme in the short term, it is equally important to have a sound long-term strategy at our disposal. The current course is not likely to be adequate in the long-term, given the present choice of feedstock's, status of technology and available policy. A substantial research thrust on the development of second and third generation feedstocks is crucial to address the future bio energy needs of the country.

The Indian Directorate General of Foreign Trade (DGFT) has imposed new restrictions on biofuels imports[23] including ethyl alcohol and other denatured spirits, biodiesel (containing less than 70% of petroleum oils), petroleum oils and oils obtained from bituminous minerals other than crude (containing 70% or more of petroleum oils). Previously free, the import of these items will now solely be allowed for non-fuel purpose on actual user basis as per the National Biofuel Policy[24]. India plans to triple its ethanol production from 1.4 to 4.5 billion litres by 2022, in order to reduce oil imports by INR 12,000 crore (US$1.7bn) and plans on adopting a B10

target (10% ethanol blending) by 2020 and a B20 (20% blending) by 2030. As many as 12 biofuel refineries have been announced[25]. The government aims to achieve 10 percent ethanol blending in petrol by 2022 and 20 percent by 2030.

## 7. CONCLUSION

According to the OECD-FAO Agriculture Outlook 2018-27[26], the demand for bio-fuels is shifting towards developing countries, which are increasingly putting in place policies that favour a domestic bio-fuels market. Looking at the potential of biodiesel production in India, there is an urgent need to undertake research by public sector OMCs to achieve higher yield of feedstock, developing short duration crops and *jatropha* cultivation through planned varietal improvement programmes, particularly in a few selected areas of the country to establish its viability. Finally, the principal changes in policy required are a multi-feed feedstock approach, an attractive incentive mechanism, both at the feedstock stage as well as biodiesel production stage, and research & development for increasing the yield from feedstock. Bio fuels offers great opportunity to increase farmers' income, import reduction, employment generation, and waste to wealth creation.

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