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Biofuel Production in India: Potential, Prospectus and Technology

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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 biofuel 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 biofuel 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 biofuel as a second generation biofuel 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 biofuel 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; Algae; Cellulosic Ethanol; Jatropha; India

Introduction

Bio-diesel production is in rise day-by-day basis in India as well as foreign countries. The major reason behind the phenomena is the limited amount of petroleum product reservoirs. Oil was the largest contributor to our global energy needs at 33% of total consumption, followed by coal (30%), natural gas (24%), hydroelectricity (6%), and nuclear power (5%). Cumulatively, fossil fuels provided 87% of the world's energy in 2011, which was actually a tiny fraction higher than in 2010 (86.9%). However, if we add nuclear power, fossil fuels plus nuclear power provided 92.1% of all energy in 2010, and declined a tiny fraction to 92.0% in 2011 because of a slight decline in nuclear electricity [1].

The fast depleting reservoir of fossil fuel has already ringed the alarm bell. The economic growth of India in the range of 5-9% and that of China around 10% has raised question marks on longevity fuel supply in international markets. If effective and forceful steps not taken immediately then in very near future the human society will back to the age of no technology system. However, searching of alternates has been initiated very long-time and recently also started yield positive results. Though, the results are not that much promising in many fields but capable to provide sustained energy resources to the human kind. The sustained and renewable energy sources includes solar, wind, biomass, sea-tide, geo-thermal, nuclear etc. As we are more comfortable using energy from fossil fuel, we would like to replicate the fuel from available renewable sources. So, we can use the fuel in the existing systems (automobiles, industries etc.) without altering the major components. Hence, the bio-diesel gained quicker popularity as a source of renewed energy among the planners, researchers and users Table 1 [2].

In the past era, the planners and Government organizations discourage the research works on renewable energy sources and use of free energy citing that the cost of fossil fuel is low and also abundant being created from nature. As time progress the fuel cost increases and the surveys confirmed the limited quantity of fossil fuel availability in the planet. The developed nations have already waked up to the call for generating new and renewed energy sources and the developing countries such as India; China etc. should up the ante and show their strong support to the underlined attempts.

The U.S. (48%), Brazil (22%), and the European Union (17%) account for 87% of global biofuel production in 2011. Current target (Figure 1) of USA is to produce 136 billion of biofuel [3].

Biofuel history

The use of renewable energy such as solar energy, hydropower, wind etc. can be traced back to the beginning of the modern civilization. But, the concept of bio-fuel or bio-diesel was used in later part of the previous century. Here we consider the biomass, as the source of renewable energy, which is converted to methanol or ethanol etc. and mixed partially with diesel (up to 5%) to use in diesel engines (in automobiles, industries etc.). In future, the bio-fuel may be used without mixing with existing fossil fuel such as diesel (B100) or petrol etc.

The history of biodiesel goes back to the era of development of diesel engine by Mr. Rudolph Diesel in 1890s. He suggested of using vegetable oils as biofuel in the diesel engine in the remote areas where diesel is not available [4]. In-fact, in late 1800s, Corn derived ethanol was first used to power early cars such as Henry Ford's Model-T [4]. But, modern biodiesel fuel, which is made by converting (trans-esterification)

Vegetable oils into compounds called fatty acid methyl esters, has its roots in research conducted in the 1930s in Belgium. And, the Pacific Biodiesel became one of the first biodiesel plants in the United States in 1996, establishing a biodiesel production operation to recycle used cooking oil into biodiesel on the island Maui in Hawaii [4]. The biodiesel production got boosting after the 2001 due to skyrocketing

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Item/year	2006/07	2007/08	2008/09	2009/10
Sugar production/1(Million tons)	28.4	26.4	15.3	18.9
Molasses production (Million tons)	13.31	11.31	6.88	8.4
Potential alcohol production (Million litres)	3195	2700	1650	1950
Demand (Million Litres)				
Portable liquor and other use	1550	1660	1680	900
I: Ethanol for 5 percent blending	600	650	700	820
I: Total demand (including 5% EBP)	2150	2310	2380	1720
I: Surplus/shortfall (Million litres)	+1045	390	-730	230
II: Ethanol for 10% blend with gasoline	1200	1300	1400	1640
II: Total demand(including 10% EBP)	2750	2960	3080	3390
II: Surplus/ shortfall	445	-260	-1430	-590

Table 1: Fuel ethanol scenario in world

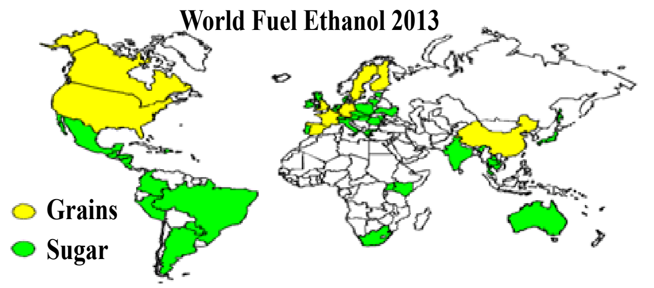

Figure 1: World fuel ethanol scenario (Source: Ministry of economy and Industry, Japan)

price of the petroleum byproducts. Due to its clean emissions profile, ease of use, and many other benefits, biodiesel is quickly becoming one of the fastest growing alternative fuels in the world.

Production techniques

Biofuel production techniques widely vary, depending on the type of raw material, efficiency level, production volume, surrounding situation and end-users requirement etc (Table 2 and Figure 2).

Algae biodiesel

Algae are aquatic oxygenic prototroph. 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 [5]. 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 [5]. 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 [6].

Synthetic biodiesel

Cellulose is a polymer of sugar. Polymers are large molecules made up of simpler molecules bound together much like links in a chain [7]. 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 4 [8]. 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 the RFS [7].

Limitations with biofuel

Biofuel is the new requirement of the global society. A number of researches have been carried out in different part of the world on alternative source of energy. The renewable sources have a major concern of lack of continuous supply of energy to the users, as the resources are discrete in nature. Secondly, in most of the sources are overestimated. For instance, *Jatropha* is considered as one of the most promising technology, but, later found unsuitable in terms of high investment to seed productivity ratio. It has gradually been discontinued in India. In US, the year's mandate for 2011, was supposed to be 100 million gallons of cellulosic biofuel, but that was reduced to 6.5 million. Thirdly, there is debate on the use of edible oil and feed for biofuel production.

Biofuel resources 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 [9]. 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 *Jatropha* Oil Extractions Private Limited etc.

It is wise to consider the oil yield potential of different edible and non-edible crops (Table 3), 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, sunflower, 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 [4]. The detailed agricultural biofuel potential of India is estimated Table 4 [10].

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 2017 (Table 5).

Algae have been in contention as one of the major source of biodiesel in near future. Cultivation of algae does not necessarily need

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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 [6]. Various studies in design of Raceway ponds with varying design parameters like water depth, stirrer design, 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 [11].

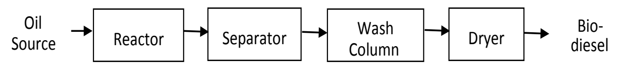

Figure 2: Stages of biodiesel production

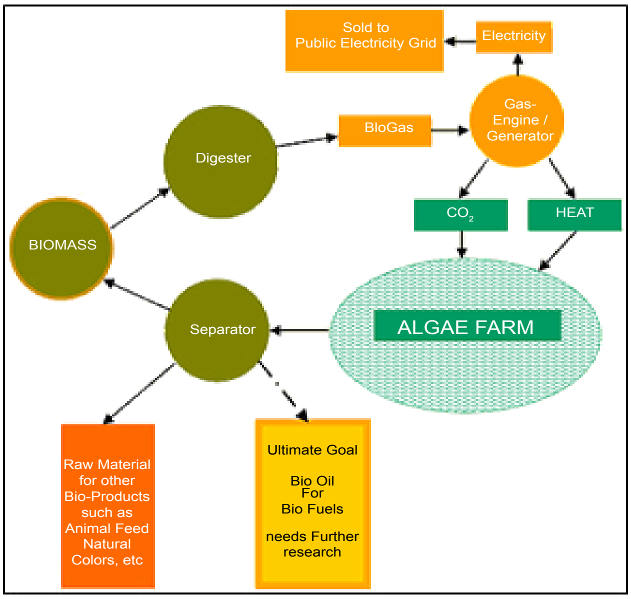

Figure 3: Algae processing (Source: Next Oils, Australia).

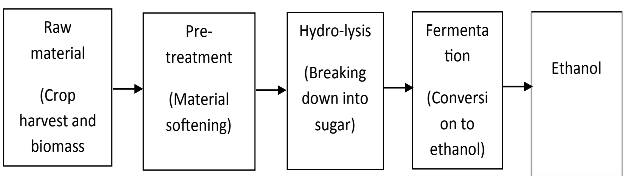

Figure 4. Production of ethanol from cellulose.

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 [12]. Open pond system is 10 times less expensive compared to photo bioreactors [13]. 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 [14]. 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 [15].

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 [16]. 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 [17]. 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 [18].

Raw material	Technique	Product	Product type
Vegetable oil and animal fat	Hydrotreatment	Biodiesel	Hydro-treated biodiesel
Algae	Fermentation, extraction and Esterification	Biodiesel etc.	Algal biodiesel
Lignocellulosic material	Advanced hydrolysis & fermentation	Biomass-to-liquids (BTL): Fischer-Tropsch (FT) diesel synthetic (bio) diesel	Synthetic biodiesel
Lignocellulosic material	Advance hydrolysis and fermentation	Cellulosic bioethanol	Bioethanol

Table 2: Production technique of biofuel

Sl. No.	Crop type	Oil yield potential ('000 l/ha)	Sl. No.	Crop type	Oil yield potential ('000 l/ha)
1	Microalgae	47.5-142.5	5	Rapeseed	1.2
2	Oil Palm	6.0	6	Sunflower	1.0
3	Jatropha	2.0	7	Soybean	0.5
4	Canola	1.25	8	Corn	0.2

Table 3: Oil yield potential of different crops.

Crop	Residue type	Prod. (tons)	RPR	Res. (dry wt.)(tons)	Sustain.Res.(20%)	Biochem.EtoH-low (litre)	Biochem EtoH-high (litre)
Rice	Straw/husk	9.60E+07	1.8	1.73E+08	3.46E+07	3.80E+09	1.04E+10
Wheat	Straw	8.70E+07	1.6	1.39E+08	2.78E+07	3.10E+09	8.30E+09
Jawar	Stalk	7.00E+06	2	1.40E+07	2.80E+06	3.00E+08	8.00E+08
Surgar cane	Bagasse/ leaves	3.42E+08	0.4	1.37E+08	2.74E+07	3.00E+09	8.20E+09
Bajra	Straw	1.04E+07	2	2.07E+07	4.10E+06	5.00E+08	1.20E+09
Maize	Stalk/cob	2.17E+07	2.5	5.43E+07	1.09E+07	1.20E+09	3.30E+09
Gram	Waste	8.20E+06	1.6	1.32E+07	2.60E+06	3.00E+08	8.00E+08
Tur (Arhar)	Shell/ waste	2.90E+06	2.9	8.30E+06	1.70E+06	2.00E+08	5.00E+08
Other cereal	Stalk	4.60E+06	2	9.10E+06	1.80E+06	2.00E+08	5.00E+08
Total					1.36E+08	1.50E+10	4.10E+10

Table 4: Biofuel potential from agricultural crops in India.

Alcohol requirement (M ltrs)	2011-12	2012-13	2013-14	2014-15
Portable Sector	1550	1660	1780	1900
Industrial Sector	1100	1160	1210	1280
Blending (5%)	1090	1150	1200	1260
Total alcohol requirement	3740	3970	4190	4440
Highest expected availability	2400	2400	2400	2400
Deficit	1340	1570	1790	2040

Table 5: Alcohol potential of India.

Way forward

McDermott has claimed of reducing the cost of algae biofuel production by 40% with the new process. The key advantage of this new process, he says, is that it uses a proprietary solid catalyst developed at his company instead of liquid catalysts used by other scientists today [19]. First, the solid catalyst can be used over and over. Second, it allows the continuously flowing production of biodiesel, compared to the method using a liquid catalyst. Biofuels will become increasingly competitive," said Rapier. "I'm not looking at where things are now, but where things are going."

References

1. Rapier R (2012) Renewable Energy-Facts and Figures. Energy trades report.
2. Tuli DK (2011) Opportunities in 2nd generation biofuel-current status. Petrofed, Indian oil corporation limited, New Delhi, India.
3. GRFA (2013) Interactive world biofuel maps. Global Renewable Fuel Alliance.
4. http://www.sippin.com/history_of_biofuel.htm.
5. Harayama S (2012) Biofuel production in algae: Towards its commercialization. Research Report-Education Course, Faculty of Science and Engineering, Chao University, Japan.
6. Chanakya HN, Mahapatra DM, Sarada R, Abitha R (2013) Algal biofuel production and mitigation potential in India. Mitigation and Adoption Strategies for Global Change 18: 113-136.
7. Mosier NS (2012) Cellulosic ethanol-biofuel beyond corn. Bio-energy: Fueling America Through Renewable Resources, Purdue extension Review Report.
8. Mosier N, Wyman C, Dale B, Elander R, Lee YY, et al. (2005) Features of Promising Technologies for Pretreatment of Lignocellulosic Biomass. Biores Techno 96: 673-686.
9. Energy Statistics Report (2003) New Delhi: Central Statistical Organization. Ministry of Statistics and Programme Implementation, Government of India, New Delhi, India.
10. Ackom E, Purohit P, Fischer G (2013) Second generation biofuel potential in India: Sustainability consideration. 8th Conference on Sustainable Development of Energy: Water and Environment Systems. Dubrovnik, Croatia, Dubrovnik-Neretva.
11. Sivasubramanian V (2013) Algal Biofuels: Indian Scenario. Sahyog Mini-Symposium and Twinning Workshop- Developments in Sustainable Biomass Valorisation EU-India R&D Collaboration in Biomassa and Biowaste, Utrecht, Netherlands.
12. Maeda K, Owada M, Kimura N, Omata K, Karube I (1995) CO_2 fixation from the flue gas on coal-fired thermal power plant by microalgae. Energy Convers Manage 36: 717-720.
13. Sheehan J, Dunahay T, Benemann J, Roessler P (1998) A look back at the U.S. Department of Energy's Aquatic Species Program: biodiesel from Algae. National Renewable Energy Laboratory, pp: 1-328.
14. Krishnan GS (2013) Can second generation ethanol fuel India's growth? Opnion on Chemical Industries. Business Standard.
15. Singh S (2013) Praj Industries Revs up Cellulosic Ethanol Plan. India Frobes, India.
16. Reddy BVS, Ramesh S, Kumar AA, Wani SP, et al. (2008) Biofuel crops research for energy security and rural development in developing countries. Bioenerg Res 1: 248-258.
17. Shinoj P, Raju SS, Joshi PK (2011) India's biofuel production programme: Need for prioritizing alternative options. Ind J Agricul Sci 81: 391-397.
18. Bhardawaj A, Tyagi R, Sharma BK, Rawat A (2013) A Review of Biofuel Policy in India: Current Status and Future Perspectives. Int J Appl Eng Res 8: 1907-1912.
19. McDermott M (2009) Forty percent cheaper algae biodiesel production technique touted. Tree Hugger, United Environment and Energy LLC, New York, USA.