



Challenges and opportunities for the application of biofuel



Girdhar Joshi^{a,b,*}, Jitendra K. Pandey^b, Sravendra Rana^{b,c}, Devendra S. Rawat^b

^a Department of Chemistry, Government (PG) College Gopeshwar, Chamoli 246401 India

^b Department of Research & Development, University of Petroleum & Energy Studies, Bidholi, Dehradun 248007 India

^c Martin Luther University Halle-Wittenberg, Halle (Saale), Germany

ARTICLE INFO

Keywords:

Bio-fuels
Challenges
Bio-fuel policy
Bio-ethanol
Biodiesel
Sustainability

ABSTRACT

Global social and economic developments are mainly driven by energy. Growing energy demand and environmental consequences have led towards alternative renewable and sustainable energy technologies world-wide. Being the 4th largest primary energy consumer globally, India's energy demand and challenges are multipronged. Considering this, India has initiated one of the world's largest alternative energy programs including solar energy, wind energy, hydro energy, biomass energy etc. Among those, the biomass based energy has been considered as the most promising source of petroleum fuel alternative. In India the biomass derived liquid biofuel have emerged as primary alternative energy source to meet its petroleum fuel demand. This article is mainly focused on to review the feasibility and challenges of liquid biofuel production technologies, associated challenges and constraints in their effective commercialization to meet the energy demand of India. The current biofuel scenario of India and its future perspectives are also elaborated in the present study.

1. Introduction

The remarkable progress of industrialization, modernization in life style and vehicular population of the world has led to significant increase in petroleum based fuel demand [1,92]. Presently, more than 80% of primary energy demand of entire world is met by the petroleum based fuel, out of which ~60% of share is consumed by transportation sector. Escobar, Lora [37]. Continuous over exploitation of petroleum fuel reserves to fulfill current energy demand have led to the rapid depletion of these energy sources. Continuous growth and fluctuation in crude oil prices along with major contribution in greenhouse gases (GHGs) emissions by their consumption [126,24,26,33], causing several negative impacts on human health along with earth's ecology. Therefore, it is essential to find out new alternative energy sources those must be renewable, sustainable, environmental friendly, efficient

and economically viable [4,81]. Among many alternative energy sources, biofuel have gained greater attention across the globe because the biofuel are considered the most sustainable and environment-friendly energy source. Generally biomass derived liquid, solid and gas fuel are broadly known as biofuel (e.g. methanol, ethanol, bio-diesel, bio-oil, FT (Fisher Tropsch)) diesel, hydrogen and methane [12,31]. The purpose of this manuscript is to review the status of India's liquid biofuel production (biodiesel and bio-ethanol), associated challenges and constraints for their effective commercialization to meet the country's energy demand.

1.1. Biofuel

According to International Energy Report 2014, global energy demand is expected to grow by 37% by 2040. Owing to limited and

Abbreviation: AD, Anaerobic digestion; ASTM, American Society for Testing and Materials; B10, Biodiesel-diesel blend (10:90); B20, Biodiesel-diesel blend (20:80); B5, Biodiesel-diesel blend (5:95); BIS, Bureau of Indian Standards; BTL, Biomass to Liquid; CAGR, Compound annual growth rate; CCR, Conradson Carbon Residue; CDM, Clean Development Mission; CFPP, Cold filter plugging point; CH₄, Methane gas; CO, Carbon mono-oxide; CO₂, Carbon dioxide; CSIR, Council of Scientific & Industrial Research; CSMCRI, Central Salt & Marine Chemicals Research Institute; DIN, Deutsches Institut für Normung; DME, Dimethyl ether; DST, Department of Science & Technology; DBT, Department of Bio Technology; E20, Ethanol-diesel blend (20:80); EBPP, Ethanol blended Petrol Program; EIA, Energy Information Administration; EJ, Exa Joules; EN, European; FAAE, Fatty acid alkyl ester; FAME, Fatty acid methyl ester; FT, Fisher Tropsch; GHGs, Greenhouse gasses; GOI, Government of India; H₂, Hydrogen gas; H₂S, Hydrogen sulphide gas; H-Bio, Biohydrogen; HCs, Hydrocarbons; HSD, High speed diesel; HT oil, Heat transfer oil; IEA, International Energy Agency; IOC, Indian Oil Corporation; IRENA, International Renewable Energy Agency; K, Kelvin; koge, kilogram oil equivalent; kWh, kilowatt hour; LC ethanol, Ligno-cellulosic ethanol; LFG, Landfill Gas; lge, liters of gasoline equivalent; LPG, Liquid petroleum gas; Mag, Ministry of Agriculture; MNRE, Ministry of New & Renewable Energy; MPNG, Ministry of Petroleum & Natural Gas; MST, Ministry of Science & Technology; N₂, Nitrogen gas; NBM, National Biofuel Mission; NBDB, National Biofuel Development Board; NOx, mono-nitrogen oxides NO and NO₂; O₂, Oxygen; OECD, Organization for Economic Co-operation and Development; s, seconds; SNG, Substitute natural gas; SYN gas, Synthesis Gas; WEO, World economic outlook

* Corresponding author at: Department of Chemistry, Government (PG) College Gopeshwar, Chamoli 246401 India.

E-mail addresses: drjgirdharjoshi@yahoo.in (G. Joshi), jkpandey@ddn.upes.ac.in (J.K. Pandey), sravendra.rana@chemie.uni-halle.de (S. Rana), devendra@ddn.upes.ac.in (D.S. Rawat).

<http://dx.doi.org/10.1016/j.rser.2017.05.185>

Received 9 May 2016; Received in revised form 18 March 2017; Accepted 21 May 2017

1364-0321/ © 2017 Elsevier Ltd. All rights reserved.

depleting resources of traditional petroleum fuels researchers are making their best attempts to meet the energy demand and finding out alternatives from renewable raw materials. The renewable energy technologies may not only fulfill the world's energy demand, but are also important parameters to reduce the emission of greenhouse gases [113]. Although, there are several ways to produce fuel from renewable resources; however, their commercial productions still an unfinished task [129]. Sources of non-edible raw materials are of great potential to produce biofuel, mainly because of the limitation of direct food and parallel race associated with biofuel [10,129,59,60].

Selected social, economical, environmental and technical issues for biofuel generation have been discussed in the form of several articles and scientific journals [100,2,49,75,88,96]. The main parameters regarding biofuel production are carbon emission levels and nitric oxide (NO₂) emissions including energy consumption and environmental issues [10]. Developed countries are having their research targets to develop biofuel industry, in particular for transport sector. Growing concerns in many developing countries to upgrading of biomass for acceptable climate and employment creation has been focused, as this is a labor intensive area. Besides, the restoration of degraded land through biomass-energy production is also of interest in some areas.

The common process of development of biofuel may as shown in Fig. 1. In general, bio-fuel can be classified as follows:

1.1.1. **First generation biofuel** is derived from starch, sugars, fats and vegetable oil that can be categorized as follows

- i. **Biodiesel:** European countries are using such type of bio-fuels mainly produced by transesterification process, similar to the mineral diesel and applicable with various engines with some additives [73,88].
- ii. **Vegetable oil:** Cooking purpose oil may also be converted to biofuel; however, this is not considered as a feasible method as it is directly affecting the food security issues.
- iii. **Biogas:** Anaerobic digestion of the organic materials generates the biogas by the process called biodegradation, where chain scission is mediated by microbes. After the conversion of bio-gas some non-harmful residue are also helpful for generating bio fertilizers [98]. Methane rich biogas is recovered using a sequential treatment. Biogas can also be generated from landfills; however, chamber controlling is very essential as methane can release to the atmosphere.
- iv. **Alcohols:** Fermentation of long chain bio-polymers such as starch and cellulose may generate the different types of alcohols mainly ethanol with some butanol and propanol. Recently it has been experimentally shown that butanol can be use directly instead of gasoline [123,40,99].

- v. **Syngas:** Indirectly, syngas can be produced through bio-fuel after converting it into carbon mono-oxide followed by pyrolysis. Xie, Kong [134]

Ethanol and biodiesel are commonly used biofuels in engines and the following section will emphasize on the technological development particularly in these areas of research.

1.1.2. **Second generation bio-fuel**

As per the IEA (International Energy Agency) Bioenergy Task 39, 2009, Biofuel derived from cellulosic biomass (cellulose, hemicellulose and lignin) with more sustainable fashion are known as second generation biofuel. The second generation biofuel are generally called the carbon neutral or carbon negative in terms of their impact on carbon dioxide concentration [91]. Comparatively easier abundance of non-fodder feedstocks from plants makes it more economical in comparison to first generation biofuel [137,44,91]. The second generation biofuel, like bioethanol, biodiesel, Dimethyl-ether, bio-SNG FT diesel etc., can be produced through hydrolysis, fermentation (*i.e.* bioethanol) esterification and/or gasification [117,91]. Bioethanol has been considered as a substitute of gasoline; whereas, FT-diesel or BTL (biomass to liquid) is used as a substitute for conventional diesel [88]. However, SYN gas can be converted in to liquid hydrocarbons mainly diesel, kerosene, methane and DME [134]. The conventional petroleum based fuels when blended with 2nd-generation biofuel may be used either as an alternative for existing internal combustion engines or get distribute through existing infrastructure or dedicated as fuel for slightly adapted vehicles with internal combustion engines (e.g. vehicles for DME)" [114]. These second generation biofuel can be supplied or distributed through existing infrastructure without any significant modifications. Table 1 presents the generation of this class of bio-fuel by various processes.

1.1.3. **Third Generation bio-fuel**

The concept of third generation biofuel is mainly refers to algae based biofuel, because of much higher quality yield of biofuel (Holds up to 9000 l of biofuel per hectare, which is to produce 10 times more than the best traditional feedstock) in comparison of other fuel generation feedstock along with a wider variety of fuels/other valuable chemical such as bio-methane, biodiesel, bio-ethanol, bio-butanol, vegetable oils gasoline, and jet fuel [18,91]. In addition, the main advantage of algae biomass is that, they can grow over a variety of carbon sources, *i.e.* they grow directly on the carbon emission sources (power plants, industry, etc.) to convert the emissions directly into usable fuel [77], with zero emission of carbon dioxide. The prime challenges associated with 3rd generation biofuel are the cultivation of microalgae at very large scale in order to meet the demand of industry, as they require plenty of water, nitrogen and phosphorus [121]. Thus, the production of fertilizers, require for the growth of algae, required much more energy and generate greenhouse gases than the product can contribute in green climate [121,77].

According to the joint nature conservation committee (Gov of UK) report on biodiesel and bioethanol in 2009; the global market for biofuel is expected to grow by 247 million USD by ~ 2020. There is a

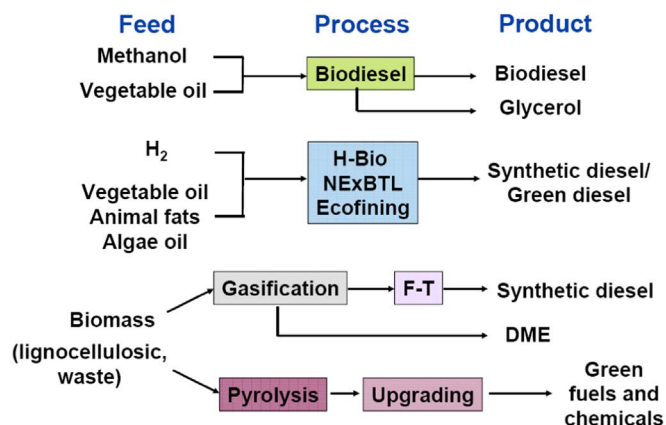


Fig. 1. Process of using various feedstocks to extract the different biofuel.

Table 1
Processes of production of second generation bio-fuel [3].

Process	Bio-fuel
Fermentation / enzymatic hydrolysis	Ethanol from cellulose
Gasification	Fischer-Tropsch biodiesel, Butanol, Dimethyl ether
Methane	Natural gas from synthesis
Hydrogen	Gasification, product of biological processes

Download English Version:

<https://daneshyari.com/en/article/5482608>

Download Persian Version:

<https://daneshyari.com/article/5482608>

[Daneshyari.com](https://daneshyari.com)