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A study on conceptual framework of biofuel generations and blending of biofuelsin India

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Abstract
Owing to the increase in the demand for energy supplies and escalating issues about greenhouse gas emissions (GHG), biofuels have received much more interest nowadays. Biofuels supply the liquid energies for transport. Biofuels generations are classified as built on the feedstock spent for biofuel construction. These are bifurcate into First, Second, Third, and Fourth-Generation. Using edible biomass in first-generation biofuels has aroused criticism because it clashes with global food needs. And Non-edible biomass is being used in second-generation biofuels are still several restrictions in terms of rate-efficiency if grading production up to a profit level. And the progress of the 3rd and 4thgenerations of biofuel is yet in its beginning phases. This conceptual study shows the generations of biofuel based on the feedstock availability & other factors and the Statistical significance of blending percentages of bio-ethanol in India.

Keywords: biofuels generations, biomass, ethanol, energy blending

Introduction

Man found energy from the fire throughout the wood-firing, which would be the first and foremost form of biofuel energy used in the early ancient periods before having conventional sources like fossil fuel, gas, coal, oil, and other energy sources. Man explored many more on biofuels, which are till reached to produce transportation fuel from biofuel sources and the beginning inventors like Nikolaus August Otto. Rudolf Diesel, Henry Ford, and others invented ethanol for running diesel engines. And many developments have taken due to the heavy energy consumption required at the time of World War II due to the scarcity of fossil fuel supplies.

Biofuels are certainly the assuring reason to decrease fossil fuel usage to fight global warming. Nevertheless, utilizing food as a feedstock for biofuels will result in significant issues shortly. Biofuel energy is one of the most ecologically approachable energy materials instead of fossil-oil-fuels. And also, an emerging potential strategy to achieve conservation and economic sustainability.

Biofuel energy is from Biomass or biowastes like living creatures, plants, and animals. And some of the crops are mainly cropped for producing biofuels like soybean, corn, switchgrass, sugar crops, jatropha, and Algae. The uses of biofuels are more popular nowadays because it is a better substitute for dipping greenhouse gas emissions, more availability, and the storage are very frequent than other kinds of conventional sources of energy. It's also viable to understand how robust the currently emerging biomass production systems are and how they contribute to better generations' abilities to satisfy their own needs. Scientists have developed standards and indicators for weighing the long-term feasibility of biofuel-producing arrangements for this purpose. In general, Socio, Economic, and Ecologically sustainable parameters to be differentiated. Most research on biofuels' long-term viability has so far concentrated solely on environmental emissions (as per LCA studies) or on aninadequate number of indicators and feedstock harvests. This study focuses on the generations of biofuel concerning feedstock availability, discusses the status of Indian biofuel production and the blending policy of biofuels in India. This study is a conceptual study based on secondary data collected from different journals, research articles, books, online websites. Used basic graphical tabulation of data to present the blending percentages of Bio-ethanol in India.

Table 1: Country-wise ethanol Price

Country	The Rate in Dollar Per liter (as of 22.02.2021)
USA	0.613
Brazil	0.606
Thailand	0.684
India	Sugarcane juice / Syrup–0.865 (INR 62.65)

	B-molasses- 0.795 (INR 57.61)
	C-molasses- 0.630 (INR 45.69)
	Damaged food grains- 0.712 (INR 51.55)
	Surplus Rice with FCI – 0.785 (INR 56.87)

(Source: Data retrieved from GlobalPetrolPrices.com**)**

Literature Review

India has been one of the world's fastest-developing economies and, behind the United States and China, India is the third consumer of primary energy. Until alternative fuels derived from conventional feedstocks are enabled, India's fuel energy independence would continue fragile. The crucial drawbacks figured in the first generation of biofuels, such as Technology, biodiversity, and traditional food crops. However, the potential of biofuel depends on the investments process on the technology advancement hence the higher contribution from international organizations with both public and private sectors supporting long term sustainability of energies (Ralph E.H. Sims a, 2010) [3]. The production of biofuel energy using cooking oil has already existed in the first generation of Biofuels. Recycling cooking oil or waste oil is harmful to health so, using it in producing biofuel energy is the most appropriate alternative. Esterification and transesterification processes are suitable methods for producing biofuel energy through waste oil (Anirudh Deshmukh1, 2019). Wind, sun, and water are the required sources to generate renewable energy in different methods. The United States of America (USA) is in the vanguard of the biofuels business, intending to replace 20% of transportation fossil energy with biofuel by 2022. (saladini, 2016) [12] and Biofuels are divided into four groups based on their feedstocks and manufacturing techniques: first, second, third, and fourth-generation biofuel.Researchers have focused on biofuels manufacturing using first-generation feedstocks as diesel substitute engines. Vegan's oil, Tallow, and leftover cooking oil are the feedstocks used in biodiesel in the first generations of biofuels. Although most biodiesels are from vegetable oil in the first generations, which is lead to the price of biodiesel will be higher than that of traditional fossil diesel (videsh seecharan, 2009) [1].

All nine kinds of food crops used for productions of biofuel in the first generation are not included socio-economic or biodiversity aspects and land-use change but included the resource use efficiency, quality of soil, Greenhouse gas emission, and Total production of energy (Sander C. de Vries*, 2010) [2]. The researcher explained the importance of biofuel energy in regards to instead consumption of fossil fuels. And there are some challenges like land requirements and food crops are mainly in the first generation of biofuels. And mentioned the importance of other Generations like in the second generation like a forest waste, agricultural waste, and animal waste are used for free stock and in the third generation of biofuel feedstock as algae (Lavoie, 2013) [6]. The 3rd and 4th generations of Biofuels are more viable than the 1st and 2nd generations of Biofuels because their feed stocks belong to non-food crops and biodiversity. And also mentioned more investigation processes and cost-effective processes required for achieving better & higher yields (Hayder A. Alalwana, 2019). Energy crops, agricultural runoff, woody-residue wastes are all examples of second-generation feedstocks for biodiesel production. Jatropha, Aleurites moluccana, salmon oil, Rubber tree Madhuca longifolia, tobacco seed, sea mango, and jojoba oil are the most widely used energy sources are used for this purpose. Biodiesel feedstocks can include residues from cooking oils, non-edible oil crops, restaurant grease, cow tallow, animal fats, and pork lard (M.M.K. Bhuiya, 2016) [11]. The Indian Government wants to reduce the country's carbon emissions by 30-35 percent by 2030 and recommended a goal of 20 % ethanol in gasoline and 5 % biodiesel in a diesel by then.

Bio-fuel Generations and its Feedstock in India

Three generations of biofuels have appeared from biofuel investigate and growth. Each generation has its feedstock, with its own set of potential, aids, and downsides. Biofuels made from a pre-existing row crop, like corn ethanol or soy biodiesel, are coming under first-generation biofuels. Cellulosic biomass, such as perennial grasses, is being used to make second-generation biofuels. Algae would be the 3rdgeneration biofuels, and presently only the 1stand 2nd generations are implemented in India.

The First-generation feedstock is from the Agri-collects like Sugarcane, Animal Fats, Wheat, Corn, Starch, and Vegetable Oil, etc. are used to produce ethanol or biodiesel. And in First Generation Biofuels are usually in the form of Bio-alcohol, Bio-diesel, Vegetable Oil, Bio-ethers, and Biogas. Vegetable oil, starch, or sucrose are frequently feedstock to yield 1stgeneration biofuels. Simple biochemical treatments for vegetable oil to biodiesel or starch and sucrose to ethanol utilize to transform these ingredients into fuel for vehicles. The food business has already developed these technologies, eliminating the necessity of further research and development before creating transportation fuels. However, such crops require a lot of agricultural input (fertilizer), while perennial grasses require less.

In the Second-Generation Biofuels, the feedstock such as lignocelluloses biomass, woody yields, remains of agriculture, straw, Bagasse, perennial gasses, jatropha, waste vegetal oil, and civic hard left-over, etc. Cellulosic biomass sources such as yield remain, returning grasses, and trees are viable for 2ndgeneration biofuels. They can be grown on marginal cropland where row crops are expensive. The key objective is to eliminate competing with the fertile ground more effectively. Cultivation of food crops focuses on the regional basis that is highly erodible or the soil with marginal quality. Transporting enormous amounts of biomass can also be a logistical and economic challenge for producers.

In the 3rdGeneration, Bio-fuel energy is in the form of Microalgae. Usually, Algae is production involves different methods such as Photoautotrophic, Heterotrophic, and Mixotrophic and then included in the harvesting of Algae through Bulking method process. Algae biomass or oil is the harvest to make 3rdgeneration biofuels. Oil-producing algae (also called Oilgae) grows faster and does not require pre-treatment. Controlling the environment for optimal growth, on the other hand, is complex and expensive. Keeping calm environmental control often involves the procurement of costlier facilities and equipment. The Fourth-Generation of Biofuels is produced from modified microorganisms like microalgae, cyanobacteria, yeast, and fungi and used as sources for feedstock. Heritably engineered microorganisms, microalgae, yeast, fungus, and cyanobacteria are the feedstock of fourth-generation biofuels. Microorganisms' potential to transform CO2 into fuel via photosynthesis is applied (S.V. Vassilev, 2016) [10].

For first, second, and third-generation of biofuels, the esterification, and transesterification processes are the same. As a result, the feedstock is the primary dissimilarity among the 2ndand 3rdgenerations. When compared to lignocellulosic biomass, algae harvest biomass sooner and on a smaller land-dwelling surface. To meet growing global demand for energy sectors would result in the depletion of the world's oil resources, biofuels' future may not rely entirely on one generation, but rather on a combination of the three generations.

Blending Percentages of Bio-Ethanol in India

Ethanol is a kind generated from biofuel, produced from organic stuff. The majority of the car fuels we use come from the gradual geological process of fossilization, which is why they're also called fossil fuels. In India, ethanol is made from sugarcane using a fermentation procedure. Because ethanol has a high oxygen level, it permits an engine to burn gasoline more thoroughly. It is also added with various amounts of fuel to help reduce vehicle emissions. It is known as renewable fuel because it is reproducible from plants (natural elements).

Although Prime Minister Narendra Modi has accelerated the introduction of a 20% ethanol blend for gasoline, the concept is not new. According to the NITI Aayog and the Ministry of Petroleum and Natural Gas' report, Roadmap for Ethanol Blending in India 2020-25, the Centre "started pilot projects in 2001 when 5 percent ethanol-blended fuel was supplied to retail outlets."(https://www.niti.gov.in/, n.d.) Even though biodiesel burning produces CO2, it's also classified as "carbon neutral" by the Intergovernmental Panel on Climate Change (IPCC). Although CO2 is ingested and stored by crops throughout their formation when crops are burned in the atmosphere, the net CO2 release is nil. The Institute of Bioscience in India recently calculated the number of carbon emissions saved by combining ethanol and biodiesel. Plantations, also the blending of biofuels, would create massive carbon currency. Consequently, licensing CDM initiatives, particularly in the plantations sector, has proven difficult or impossible higher financing prices, the engagement of local producers, and the absence of an organizational framework to enable CDM operations. The below table presents the blending names and their portion of blending.

Table 2: Blending Table of Biofuels (Terminology)

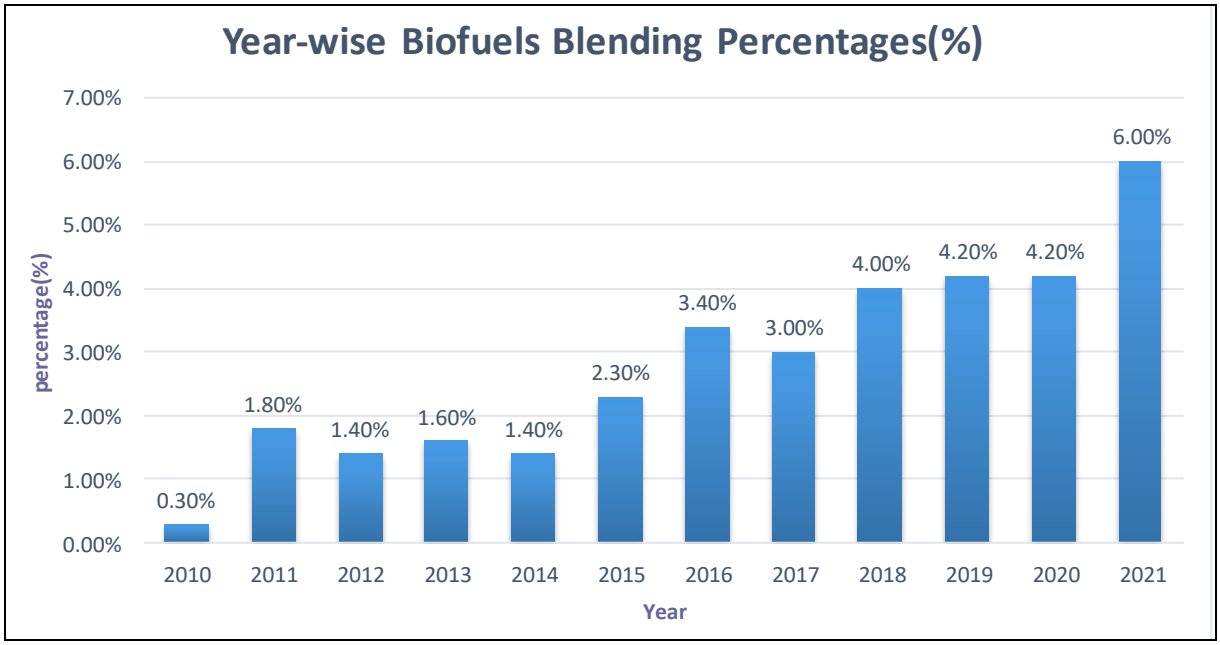
Biofuels	Meaning
B100	100% bio-based fuel
B5	5% biodiesel and 95% petroleum diesel
B7	7% biodiesel
B10	10% biodiesel
B20	Up to 20% biodiesel
B99	Between 1% and 0.1% petroleum diesel
E10	Up to 10% ethanol and 90% gasoline
E15	15% ethanol
E85	Between 51% and 83% ethanol
Renewable Diesel	Biomass-derived diesel fuel refined via hydro-processing
Cellulosic Biofuel Blends	Non-food-based biomass

(Source: Data retrieved from Targray.com**)**

B100 (pure biodiesel) is a bio-based fuel made entirely of Biomass. It is common in diesel vehicles manufactured after 1994 with biodiesel-compatible parts. Vegetal oils, animal fats, used cooking oil (UCO), and algae are biodiesel feed stocks. B5 is a biodiesel blend that consists of 5% biodiesel and 95% petrol diesel. It's the most prevalent biodiesel mixture in the United States. B7 is a biodiesel mix with 7% biodiesel content. And like all biodiesel combinations that comprise between 6% and 20% biodiesel, it is popular in several countries like Germany (as road operations) and Malaysia (as industrial operations). B10 is a name used to indicate biofuel mixtures that contain 10% biodiesel, are most widely found in Southeast Asia, owing to Thailand and Malaysia's biodiesel legislation. B20 is the portion of biodiesel mix with up to 20% biodiesel content. In the United States, most diesel automotive manufacturers allow B20 to use in their vehicles. B99 is the maximum biodiesel blend, with a Petro - diesel content of between 1% and 0.1 percent. In the United States, this fuel blend is more readily available than pure biodiesel (B100).

E10 is a gasoline-ethanol mixture that contains up to 10% ethanol and 90% fuel. And it is the most popular biofuel blend on the market right now in the United States. Biofuel mixes containing 15% ethanol are known as

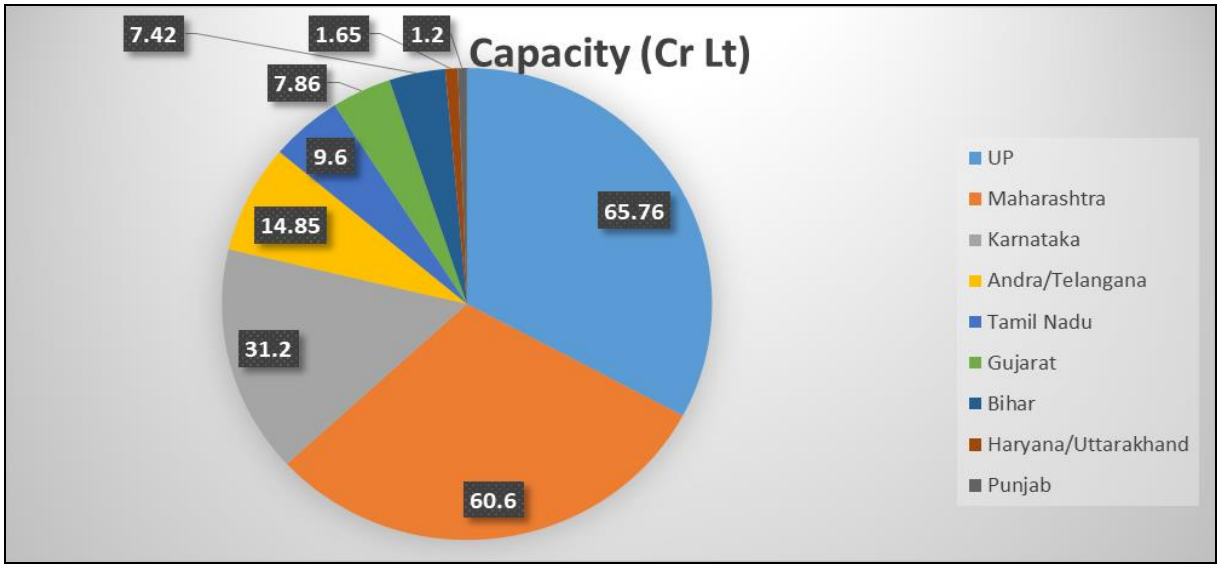
E15. E15 has also got permitted by the Environmental Protection Agency for use in vehicles manufactured later in 2001. E85 is a biofuel blending with a large amount of ethanol content, ranging from 51 to 83 percent. Only in FFVs should this blend be employed. Sustainable diesel is a hydro-processed diesel fuel made from biomass. This fuel is chemically parallel to petrol-diesel as an outcome of the purification process. Cellulosic biofuels are fuel made from biomass that isn't food, including such agricultural residue or switchgrass. Biobutanol, for particular, could be combined with another form of oil and utilized in traditional gas engines.



(Source: Data retrieved from S&P Global Platts Analytics**)**

Fig 1: India's Ethanol Blending Rate

Fig. 1 shows the blending proportion of percentages of biofuels, mainly in Ethanol. The blending proportions of bio-ethanol have enlarged simultaneously every year. And in the year 2010, the percentage of blending was 0.30% but, in the year 2021, it has reached 6%.



(Source: Data retrieved from NITI Aayog, Ministry of Petroleum and Natural Gas**)**

Fig 2: State-wise Ethanol Production Capacities

Fig. 2 presents the state-wise ethanol capacities in India. UttarPradesh stands 1st place with the highest production capacities of Ethanol; about 65.76 cr liter, followed by Maharastra and Karnataka. Punjab stands last with 1.2 cr liter of Ethanol production capacities.The main reason for the higher productions of ethanol in the Uttar Pradesh sugar sector is committed to delivering the ethanol blending initiative as a flourishing optimism-capable of achieving significantly higher volumes in the future. Increased ethanol quantities would imply more money in the manufacturers' hands, which will lead to maximum payments to the producers. The Government

initiatives in reducing administrative barriers to new project licenses increased in ethanol shipment during the last two years.

Policy Implications

Adopt the New Technologies and New Methodologies for the feedstocks of Second and Third generations of biofuels to maximize manufacturing efficiency. And the sustainability of biofuel production should be centered on cutting manufacturing costs and leveraging technological advancements to expand biofuel production.Joint Programs with Automobile-Engineering to increase the Oil-Blended-Vehicle Production to promote & diversify the usage of Biofuels, and improve the Creation capacity. And many programs must promote by federal funding in technological and scientific research & development in computation and transformation technologies with alternative feedstock products. Considering and enumerating the sustainability practices of biofuels requires ongoing improvement. Strategies to standardization, evaluation technique, prospective renewable source effective effort must have concurred. And this will have to take an account the generation of the biomass feedstock with proposed land modification & implications. And to redress the economic damage the political change is also required. The fair impacts of contemporary biofuels mix use on engine working conditions and operation necessitate greater consumer engagement.

Conclusion

In retort to qualms about energy stream security, mounting oil values, and weather variation, the production of first-generation biofuels, primarily from traditional food yields, has increased vividly in current years. As a result of a better understanding of biofuel energy as a consequence of thorough life cycle assessments, total GHG emissions, and other related direct and indirect land-use change issues like the public's perception of the environment, Second & Third-generation biofuels manufacture systems are still in the initial phases of progress. And require further research and analysis of process economics and process intensification to be commercialized. In India, ethanol-blend gasoline and diesel have the immense opportunity for usage as transportation fuels. Aside from the financial benefits of ethanol as an alternative fuel, it also promotes a cleaner, sustainable planet and reduces reliance on crude oil imports. To incorporate the Ethanol Blending Program (EBP) across the country, all interested parties like lawmakers, regulatory authorities, manufacturers, and OMCs should concur when assigning Ethanol as a transportation fuel.

The cause of poor development in the sector of Biofuel is marketing. So, Government requires to implement policies and initiative programs regarding the marketing of bio-diesel through promoting financial co-operations such as tax credits, higher subsidies, more investment in investigation & expansion, parade, and distribution. Thus, these are supposed to certify that the forthcoming manufacture of several biomass feedstocks is carried out sustainably and chosen adaptation skills like those that are more advanced. And those that are still in the Research & Development stage are identified and assessed for economic feasibility.

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