BIOFUELS FOR A GREENER FUTURE: THE SCIENCE AND PROGRESS

Abstract

Biofuels are composed of energy dense compounds made from biomass based on plants or microbial origin. For their utilization in transport, residential, commercial and industrial, they're capable of being a viable substitute to renewable fossil fuels. Biofuels can be classified into various generations depending on the feedstock. To foster and increase the sustainable production of biofuels, a few factors need to be considered, as well as, feedstocks, effective distillation technologies, technology readiness and policies supporting market demand. In order to enable biofuels to be economically viable and equivalent to crude oil, subsidies, financial aid, grants or market interventions are needed. The current chapter focuses on biofuels and their related production, innovations and latest developments in the branch relating to its applications, opportunities and challenges.

Keywords: Biofuels, Biomass, Feedstock, Micro-organisms, GreenHouse Gases, Renewable sources

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I. INTRODUCTION

Alternative forms of energy called biofuels are generated from organic resources like plants and algae. It falls into three categories: first-generation biofuels, made from digestible crops; second-generation biofuels, which are made from inedible sources; and third-generation biofuels, made from microorganisms and plankton. These fuels have an opportunity to provide a more sustainable energy environment by lowering emissions of greenhouse gases and reliance on scarce assets

II. TYPES OF BIOFUELS

1. **Biodiesel:** Biodiesel is relatively low in heat (39-41 MJ/kg) compared to coal (32-37 MJ/kg) and petrol (46-47 MJ/kg). Petro diesel is even lower at 43 MJ/kg, and gasoline is even lower at 42 MJ/kg [1].

   The rise in the biodiesel industry has been driven by the mitigation objectives of several countries. Biodiesel produced from biomass is expected to be “carbon-neutral” throughout its life cycle because burning only releases the carbon dioxide that the feedstock crops have absorbed through photosynthesis. More land must be cultivated to produce the oil crops needed to produce biodiesel. This has resulted in the destruction of virgin rainforest to create monocultures. Worldwide, deforestation is estimated to account for about 20% of GHG emissions. Large parts of the forest that are currently being cut down for palm oil are peatlands, which have marshy soils which are important reservoirs for methane. The growing use of food as a raw material for biodiesel has had a negative impact on hygiene, food supply and pricing [2].

2. **Ethanol:** According to the United States Renewable Fuel Standard Program (RFS), almost all gasoline ethanol produced is made from corn kernel starch, which is considered a conventional biofuel [3]. Ethanol has a 1.5 GGE (gasoline gallon equivalent) value, which means that for every gallon of gasoline, 1.5 gallons of ethanol are needed to make up the difference.

   There are several ways to produce ethanol fuel, but fermentation is the most common. Yeast based microbial fermentation of carbohydrates. Distillation. Dehydration (requirements differ; see ethanol fuel mixes, below). Denaturing (optional). The fundamental steps involved in the production of ethanol on a large scale include, fermentation, distillation, and fermentation. Some plants need to break down carbs like cellulose and starch into sugars before they can be fermented. Cellulosic ethanol is saccharized cellulose. To convert starch to sugar, enzymes are used [4].

3. **Biogas:** Ethanol fuel can be made in a variety of ways, but fermentation is the most common. It's when yeast-based microbes break down carbs. Other processes include distillation, dehydration, and denaturing, which is optional. The main steps for making ethanol on a large scale include fermentation and distillation (see below for Ethanol fuel mixes). Some crops need to be hydrolyzed or saccharide into sugars before fermentation. For example, cellulose or starch must be hydrolyzed before fermentation. Cellulosic Ethanol is saccharide cellulose [5].

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Jenbacher gas engines are distributed by Clarke Energy and are built to operate reliably with challenging gases like biogas, landfill gas, or sewage gas. Additionally, Clarke Energy distributes TPI's biogas upgrading facilities.

- **Benefits of Biogas:**
  - Coproduction of combined power and heat to produce renewable energy
  - Getting rid of troublesome wastes
  - removing trash from landfills
  - manufacturing a low-carbon fertilizer
  - preventing landfill gas leaks and cutting carbon emissions [6].

Bio methanation is the process of producing biogas. Methane, the fuel's energy source, and carbon dioxide make up the majority of biogas. Additionally, it could have trace quantities of hydrogen or nitrogen. Sulphur or siloxanes may be contaminants in the biogas, depending on the digester feedstock [7].

The following factors can affect the proportions of methane and carbon dioxide in the biogas:

- The proportion of lipids, proteins, and carbs in the feedstock
- The digester's dilution factor (water may absorb carbon dioxide)

4. **Algal Biofuels:** Algal can occasionally be farmed to create algal biofuels, the third generation of biofuels. Algae of many varieties may be utilized and processed to produce biofuel. There are many processes that must be used to turn algae into biofuel.

   - **Growing Algae:** Using sunlight, carbon dioxide, and nutrients, you can grow algae.
   - Algae harvesting removing algae from the growth cycle
   - **Oil Extraction:** removing the oil from the cake of dried algae.
   - **Biofuel Production:** Developing Biofuels from Oil and Algae[8].

5. **Syngas Based Biofuel:** Synthetic Gas, also known as Fully Synthetic Gas (FNG), is a mixture of mostly carbon dioxide and hydrogen, often with a tiny bit of carbon monoxide and methane, which is highly combustible. Synthetic gas is mainly used to produce hydrocarbons, including diesel, methanol, and industrial chemicals such as ammonia. Synthetic gas produced from waste or other biomass is sometimes referred to as renewable energy [9].

6. **Green Diesel (Renewable Diesel):** Renewable diesel can be produced using a variety of technologies. Hydrotreating can be used in a number of applications, such as in commercial oil refineries. Hydrotreating involves the reaction of the feedstock (liquid) and the hydrogen at high temperatures and pressures with a catalyst. At present, commercial refineries use hydrogen processing and the raw materials used are fats, oils, and greases. Gasification is the process by which biomass is heated to a certain temperature and transformed into syngas. The process is then catalyzed to produce hydrocarbons. Pyrolysis is a chemical process in which organic materials are broken down at high temperatures without oxygen. The resulting liquid is then refined into hydrocarbons either in a different process or to produce crude oil for conventional oil refining [10].

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Renewable diesel has several key benefits, such as:

- **Reduced Emissions:** According to an NREL study, renewable diesel fuel significantly reduces carbon dioxide emissions and nitrogen oxide emissions, compared to petroleum diesel fuel.
- **Reduced Carbon Intensity:** Renewable diesel fuel has a C02 (Carbon Emissions Per Mile) average of 65% lower than petroleum diesel, according to California's lowest carbon fuel standard certified carbon intensity.
- **Flexibility:** Renewable diesel may be blended with or substituted for diesel in any quantity and can be made from a wide range of raw materials. It can also be produced in factories that produce sustainable jet fuel [10].

III. HYDROTHERMAL LIQUIDS

Hydrothermal liquids refer to a type of biofuel produced Hydro thermal liquefaction (HTL)
HTL is a process that takes place at high pressures (10 – 25 MPa) at high temperatures (280 – 370 °C). When wet biomass reacts, the primary product is bio-oil, which is formed by the reaction of the solid, the liquid and the gas phases [11].

HTL is a process that converts biomass into liquid biofuels by thermochemically converting it to liquid biofuels over a sufficiently long period of time in a hot (or pressurized) water environment. The degradation of solid polymers typically takes place in the liquid component. Protein-rich raw materials such as food waste, manure, and sewage typically have a high moisture content and are suitable raw materials for HTL processes. Water is a critical raw material in many HTL processes. As reaction conditions get closer to the critical point, a few properties of water dramatically change and can result in rapid, homogeneous, and efficient reactions [12].

1. **Methanol:** Methanol is an alternative fuel that's been around since 1992 also called wood alcohol. It's used as a motor fuel because it has the same chemicals and properties as ethanol, but it wasn't used as a commercial fuel back then [13].

   Syngas is usually produced by the steam reforming process of natural gas.This syngas fuel is then injected into the reactor through the catalyst to create methanol and steam. Various raw materials can be used to make methanol, but at the moment natural gas is the most cost-effective [14].

2. **Renewable Natural Gas:** Renewable natural gas (RNG)* is a term used to describe biogas that has been refined to replace fossil natural gasRNG, also known as CNG/LNG, is a high-quality pipeline-grade natural gas that is 100% convertible" to conventional gas. This implies that RNG can be used to power natural gas vehicles.

   RNG is primarily composed of biogas, which is the gaseous result of the breakdown of organic matter. RNG has been treated to meet purity standards. Just as conventional natural gas is used as transportation fuel, RNG is also used as a transport fuel.

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- **Renewable Fuels:** RNG, or Renewable Natural Gas, is one of the advanced biofuels that meet the Renewable Fuels Standard [15].

3. Straight Vegetable Oil:

- **Straight Vegetable Oil** (SVO), also referred to as PVO or pure plant oils, can be modified to be powered by diesel engines. It is often seen as a sustainable alternative to Waste Vegetable Oil (WVO) or used cooking oil. A number of European countries, such as Germany, France, The Netherlands, and the UK, are engaged in decentralized, small-scale production of SVO for use in agricultural, personal cars, and municipal vehicles [16].

IV. CONVENTIONAL AND ADVANCED BIOFUELS.

1. Optimizing Biofuels by Conventional and Advanced Technology:

- Increase in biofuels production and development of different biofuels production technologies [17] has become controversial. Scenario on the other side explains that production of corn-based biofuels creates a ‘food/feed vs. fuel’ tradeoff condition.
- Subsequent uncertainties are considered for both consumers and producers (farmers) [17].

2. Emerging Advanced and Conventional Biofuels: The advanced biofuels are acknowledged to be eco-friendly, yet not available on a large commercial scale. *Eg-miscanthus, algae etc. The availability of limited resources for the production of biofuels feedstocks. Sustainable biofuels production is the major issue i.e giving an impact on decision making.

- Conventional Biofuels are commercially available and have reached technological and market maturity .The advancements in feedstock generation and processing can reduce costs and achieve greater environmental performance.
- In general, advanced biofuels are liquid fuels that are derived from non-food-based feedstock.

3. Statistical Data:

- Life-cycle reduction is yielded in greenhouse gas emissions of at least 50% compared with fossil fuels given in the below pie chart

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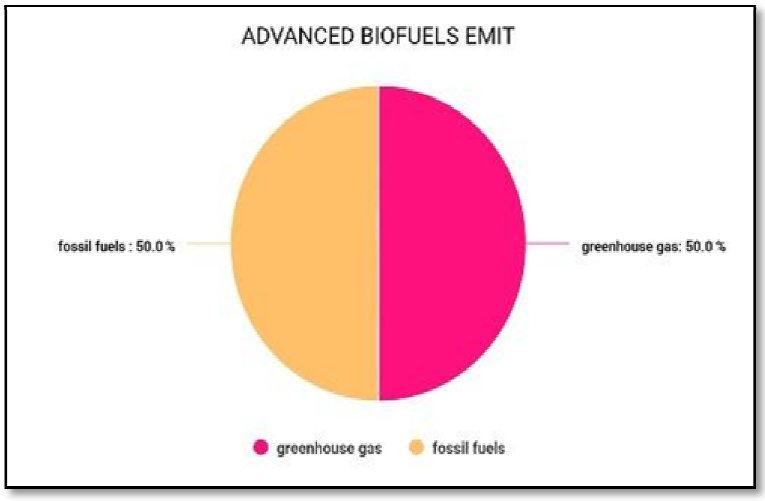

Graph1: Represents the Amount of Advance Biofuels which are Emitted

4. **Competitiveness of Advanced and Conventional Biofuels: Results from Least-Cost Modeling of Biofuel Competition in Germany:** Technologically prudent feasibility for the manufacturing of lignocellulosic biomass from advanced biofuels have been thoroughly inspected. [18]. To increase the competitiveness as in the commercial terms for biofuels a transparent model is combined. Precisely gaseous fuels, feedstock and learning effects are highlighted. Mostly conventional bioethanol and biodiesel are cost competitive biofuels. And the cost for bio-SYNTHETIC NATURAL GAS (SNG) and biomethane has been converged to medium. These factors play a vital role in the development of biofuels in terms of commercial production. [18].

5. **Quantification of Conventional and Advanced Biofuels Contents in Diesel Fuel Blends Using Near-Infrared Spectroscopy and Multivariate Calibration:**

   - Conventional biofuels or biodiesel are used increasingly, and advanced biofuels such as hydrocarbon fuel (paraffinic). They can be better known as renewable diesel, and is a feasible alternative for renewable energy sources to increase in the transport sector [19].
   - Fatty acid methyl esters (FAME), or the biodiesel, in the presence of a catalyst the conventional biofuels can give the reactant and product as transesterification reaction with methanol and triglycerides(from vegetable oil or animal fat)[18]. These days, petroleum diesel is mainly substituted as biodiesel. Because of some technical issues, common diesel engines are confined to 20% (v/v) in mixtures with petroleum.

6. **Advanced Biofuels–Potential for Cost Reduction:**

   - There is a principle for bioenergy in the global energy economy, which is cost friendly. By which in the future there will be reduction of greenhouse gas (GHG), which is sent forth by the transport sector, as well the reduced carbon in the atmosphere too.
   - These low carbon advanced fuels are suitable for long-duration transport in the administration pertaining to aviation. This has been technically and commercially

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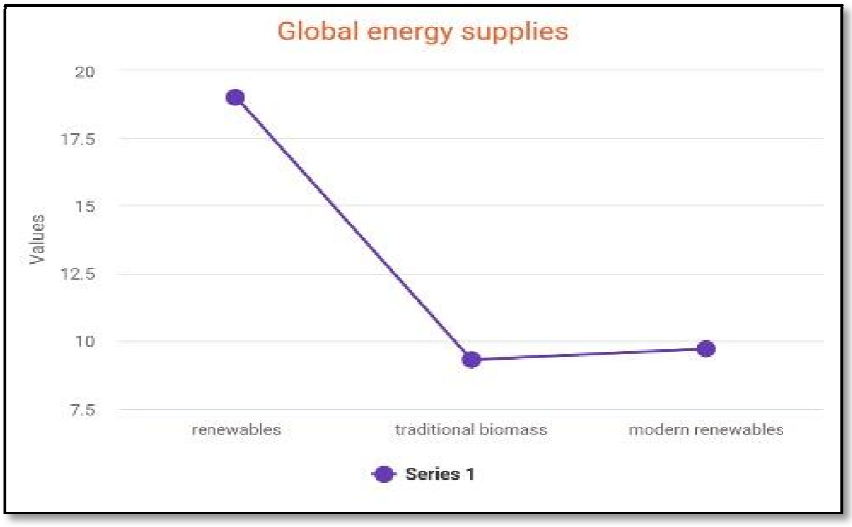
evolved for the production of fuels which scaled up the market in a limited way. This information is depicted by the researchers.

V. USES OF BIOFUELS

- Biofuels are an incredible substitute to non-renewable resources. Biofuels as per different sectors vary in the terminologies too.To be more precise for incentive programs and in industry branding government legislation varies [19].
- The names of biofuels could also be as of the uses or types of the fuel with bio (biodiesel or bio jet) or words like clean, sustainable, (such as sustainable aviation fuel), alternative, green, renewable. Biofuels can also be generalized to blending components and liquid fuels which are produced from feedstock (Biomass) [20].

1. **Microbial Pathways for Advanced Biofuel Production:** John love et al has done research in the the field of microbes for the production of advanced biofuels Subsequently since the industrial revolution, due to pollutants acquired from the industry and natural carbon cycle, with major impacts now felt worldwide[21]. The decarbonisation of the transport sector is due to biomass derived transport fuels. Which accounts for the consumption annually i.e approximately from total energy consumption is one third as given above transport which is 65% of global petroleum.

As Biofuel is known as an alternative to diesel fuel, there are other uses also Globally ethanol has now been manufactured for the production of about 44 million metric tonnes of high-quality biofuels feed. Nevertheless, the biofuels feed market puts up around just 8-9 million tonnes of a protein meal per annum for the co-products of biodiesel. According to the information illustrated by Jozeph Popp et al which is given statistically that for the last 35 years globally the energy supplies have been mostly doubled but the relative contribution from [22],firstly renewables has increased from 13% to 19%, including about 9.3% from traditional biomass and about 9.7% from modern renewables given in the graph 2 below.



Graph 2: Represents the Statistical Data of Global Energy Supplies**.**

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2. Chlamydomonas as a Model for Biofuels and Bio-Products Production:

- Chlamydomonas Reinhardtii in the field of basic research for green algae that has made the way for developing genetic engineering protocols [23] and understanding algal metabolism. reinhardtii is used as a tool for development of strains in algal species.
- Significance of algal biofuels gives assurance for the energy demands in future, in order to realize this potential refinement is needed at the production level [23].
- In prevalence for production [23]. Chlamydomonas Reinhardtii is a magnificent organism to understand and qualify bioproducts and biofuels under the algae. In this way chlamydomonas species also contribute to the production.

3. Microbial Beta Glucosidase Enzymes: Recent Advances in Biomass Conversation for Biofuels Application:

- To eradicate the current environmental issues generated from fossil fuels the biomass to biofuels production process is the only advanced, green, sustainable technique.
- Conversion of biomass to Biofuels is an enzymatic process which is mediated by the enzyme called β-glucosidase (BGL). It is significant due to the biomass hydrolysis by the production of monomeric sugars from cellulose-based oligosaccharides.
- Regardless, the availability and production of these enzymes are applicable to increase the overall production cost biofuels for production technology .Therefore, the present review is focused on evaluating the production and efficiency of β-glucosidase enzymes in the bioconversion of cellulosic biofuel production at an industrial scale, providing its mechanism and classification.

4. Techno-Economic Analysis of Sustainable Biofuels for Marine Transportation:

- Overall beyond 90% of the world trade accounts to the [24], global economy which is assisted by industrial shipping.
- On the whole in a year the energy requirement for the marine shipping [24] sector has been anticipated to increase from 10.5 to 24.5 exajoules by 2050.
- In the same way microalgae also holds the superior characteristics as feedstock for biofuel and production that has recently been given great attention [25].
- As a result, the kindling of marine HEAVY FUEL OIL HFO emits a extensive multifariousness of pollutants like, which includes sulfur oxides (Sox), nitrogen oxides (NOx), [24] particulate matter (PM), and carbon dioxide (CO_2), which account for 14 to 31, 4 to 9, and 3 to 6% of global NOx, Sox, and CO_2 emissions, respectively as shown in graph 3.

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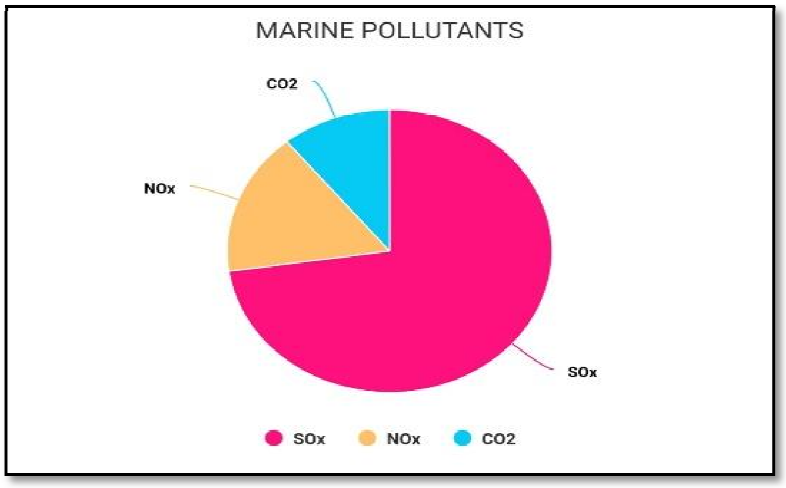

Graph: 3 Depicts the Review of Marine Pollutants.

VI. DRAWBACKS OF BIOFUELS

Despite the positive characteristics of biofuels, there are drawbacks to these sources. These disadvantages are considered as arguments against replacing biofuels for fossil fuels. As we know, fossil fuels (non-renewable) release greenhouse gases. Biofuels are renewable sources, they slow the change in climate, are easily produced, cause comparatively less pollution, plus are an efficient source of energy. Compared to fossil fuels, biofuels are much more environmentally friendly and sustainable energy sources. Though biofuels have many benefits, there are a number of challenges linked with their generation and larger scale use. Now let us explore the downside of biofuels to understand their future potential as an energy source.

1. **High Production Cost:** The generation of biofuels is more costly than the fossil fuels production because of the growing and processing cost of the feed stocks. The biofuel manufacturing expenses vary based on the biofuel types, site, and technologies. This is simply because biofuels are generated from renewable resources that are much costlier to produce than fossil fuels. If demand for biofuels increases, a rise in supply becomes a long-term operation which is too expensive.

2. **Monoculture:** Monoculture is the practice of growing the same crops every year instead of producing a variety of crops overtime. This is economically advantageous to farmers but growing one heavily concentrated crop may rob off the soil of nutrients.

   Firstly, soil consists of nutrients and micro-organisms required for crop growth. These nutrients remain ample when a variety of different crops are grown and produced. This is because each crop utilizes a single type of nutrient in the soil. If different crops are interchanged and grown, these nutrients are balanced. When a single crop is cultivated, it wears out the soil. This results in unusable soil and degradation of land on a huge scale [26].

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Secondly, hundreds and more acres of a single crop provide tempting targets for plant pests. Pests can expand uncontrollably in such an irresistible land. Deep rooted monoculture uses greater amounts of artificial fertilizer; this increases pollution in water.

3. **Technical Challenges:** Biofuels are problematic as they operate differently in cars than usual petroleum-based fuels. It is not a petroleum-based fuel; hence, works variously in engines that are created for petroleum-based fuel. Corn based ethanol has a higher density than gasoline. Alcoholic fuels can wear out and damage the metal and rubber fittings. Because of the higher petroleum gel point of various biodiesel generating oils, a biodiesel power source or engine can be tricky, or nearly impractical to work in cold weather conditions.

4. **Changes in Land Use:** The manufacture of biofuels, time and again, lead to changes in land use, including the conversion of natural habitats to farmland. To match the rising demand for biofuels, the farmers often transform natural habitats into farmlands. Land used for growing biofuel feedstock needs to be cleared, which causes damage to ecology. The local habitats, animal dwellings, and micro-ecosystems are destroyed thus, reducing the net health of the region's natural resources. The vernacular forest is forever better at eliminating carbon dioxide from the airspace compared to biofuel feedstock. This is partially because the carbon dioxide stays confined and is not ever released by burning in a manner with fuel stock, and hence Carbon debt is created.

   Estimates have earlier shown that clearing the native land can create debt in carbon that will probably take 500 years to compensate [27]. In addition to this, transforming land into agricultural land means that fertilizers will be used to get the most yields. This leads to water pollution and other agricultural pollution.

5. **Use of Fertilizers:** Biofuels are produced from plants that need fertilizers for better growth. The disadvantage of utilizing fertilizers is that they damage the surrounding atmosphere and environment and lead to water pollution and land pollution. Fertilizers contain elements like nitrogen and phosphorus, these foster rapid and healthy growth of many crops but these are often carried away from soil to nearby water bodies like lakes, rivers, or ponds. This is an issue biofuel crops share with food crops, thus expanded biofuel production associated with overuse or inappropriate application of fertilizers is a weighty pollution warning for fresh water sources [28]. Careful application of fertilizers could help to stop the widespread pollution, but increasing the production of biofuel to fulfill the demand unlocks the door for more such errors.

6. **Food Security:** Biofuels are drawn out from crops that contain high sugar levels. But, many of these are also utilized as food crops. Biofuels consume space for agriculture, which creates many difficulties. The production of biofuels compete with food production in several ways like for land, water, and other resources.

   One major worry people have is, the increased use of biofuels mean a rise in food prices and using food crops for biofuels can also result in decrease in the food availability. In the long term, this can lead to a decrease in food availability, nutritional quality of available crops, diversity of food crops, and possibly endanger food security [29]. To this day, approximately one billion people are suffering from malnourishment.

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Biofuels aren't purely adding to this issue but they do question if we can utilize the resources needed to produce energy to help terminate world hunger.

7. **Water Misuse:** Biofuels require a major amount of water for its irrigation and processing purposes, which causes water scarcity and competition against other uses. Sunlight and water are very essential prime sources for growing any crop. Large quantities of water are used to manufacture corn-based ethanol to match the demand for biofuels, which can put unendurable pressure on local water resources [26]. Different ways are searched to genetically engineer less thirsty crops. If farmers are unaware about plant crops not compatible for the region, they might end up using more water than any other crops.

8. **Economic Impacts:** The development of a biofuels industry can have both beneficial and harmful effects on the economy. For instance, the production of biofuels creates employment and promotes economic development, but on the other side it increases food prices, competes with other industries for resources. In addition to it, biofuel manufacturing also leads to changes in land use patterns as discussed earlier, which displaces local communities and increases the land price or cost.

9. **Pesticide Pollution:** Biofuel production may reduce the pesticide pollution if used sustainably. On the other hand, if formerly undisturbed natural land is made into a monoculture land, there is a high possibility that pesticide pollution will occur and affect the environment and water. Some biofuel crops are considered as high input crops that not only require large amounts of water but even large amounts of pesticides to protect them.

10. **Deforestation:** Agricultural lands are known to be pretty damaging for the environment in many ways. If we acquire biofuels on a large scale, it is natural to miss out on how much land would be needed to meet our energy needs.

    Crops may take up a lot of land, which usually leads to destroying natural habitats on which the wildlife is dependent. Clearing forests for crops will definitely put many ecosystems and their species at risk. According to estimation, extension of Indonesian palm oil plantations led to more than half of deforestation in Indonesia in the late '80s and '90s.

11. **Limited Compatibility:** Biofuels are not completely suitable for all types of vehicles and equipment. Compatibility means the ability of a fuel to be used in already extant infrastructure and equipment without any modification or damage. Biofuels are generally incompatible with traditional fossil fuel infrastructure due to their varied physical and chemical properties. For instance, bioethanol and biodiesel cause corrosion in fuel systems and engines. In addition to this, they have a higher viscosity than fossil fuels, which eventually leads to jamming or damage of fuel filters, injectors, and pumps.

12. **Weather Issues:** Biofuels are incompatible for use at lower temperatures because it is more likely to draw the moisture towards itself than when compared to fossil diesel as discussed earlier, which increases microbial growth in the engine that jams the engine filters. Every country grows crops but they are more often limited to specific types of crops based on their climate and region. This can become problematic for biofuel

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production because not every country is able to grow soy, sugar, and corn. Additionally, the fact that there are still many nations that are not able to produce their own biofuels because of their climate and region implies that they may rely on biofuels from other nations.

13. **Climate Change:** Biofuels might mitigate the effects of climate change but cannot resolve them. Just switching to a cleaner energy source does not imply that it would not add on to the current global warming. Biofuels still contribute to greenhouse gasses in our atmosphere, thus the climate crisis will definitely continue for years. We can surely cut greenhouse gas emissions but if we want to beat down this existential threat, then we should consider carefully every donor of this issue [30]. Biofuels may not be the best substitute to energy sources that have less harmful effects on climate change.

VII. BIOFUEL PRODUCTION IN INDIA VS OTHER COUNTRIES

Nowadays, the increase in population of the world and energy demands uplifted the study and use of energy through traditional ways in energy recovery systems as they are affecting the environmental conditions.Biomass biofuels did represent sustainable energy for developmental purposes and for developing countries. This review recollects about the characters and merits of solid biofuels, pre-treatments and thermal treatments required to restore energy, and compares it with traditional fossils [31]. Other areas included insight of sustainability,economic feasibility of solid biofuels. likewise explained,frequently insight of tools to elevate the environmental impact as life cycle assessment (LCA) . RecentRecent methods claim the efforts for sustainability in the biofuel industry, such as life cycle sustainability assessment (LCSA) and schemes like the Roundtable on Sustainable Biomaterials (RSB), like the Roundtable for Sustainable Palm Oil (RSPO). It was revealed that the economic feasibility, competitiveness of solid biofuels showed differences among the developing countries but represent a notable contribution to energy dimensions.

India has shown interest in biofuels. India announced 30% of fossils consumed by biodiesel and bioethanol by 2017 [32]. Policy expectations from biofuel have been a concern. Lately, the risks associated with biofuels in spite of food and land changes have raised serious concerns in developing countries. India announced a natural fuel bio policy to promote biofuel production focusing on waste areas. Presently in India most of the biofuels produced are based on conventional food such as sugarcane, oil palm etc. In India biofuel is used as a source of energy for cooking, heating and even for power generation. Cost of ethanol and biodiesel in India is Rs.20/- per liter. India is third largest Ethanol production after Brazil, and China .One important element in the rise of staple food since 2001. The question that arises is whether the trade between food and fuel is less harmful or unwarranted for developing countries and which aspects are likely to be critical. The motivation for governments to pursue biofuel development are multidimensional. Biofuel development addresses issues related to energy and food security, and rural development. Biofuel can be an integral part of emerging bioeconomy and have potential to replace materials including fuels from in the future. renewable energy, biofuels were derived from plant material that contributed to reduction in greenhouse gas emission and were replaced by fossils and they are sustainably managed. Biofuel production is associated with farmers in rural and poor areas. It has the ability of producing new income for farmers and offering new jobs to poor people and improving farmers' life standards [33].

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Biofuel production is a major factor for the increase in food prices in 2000's. The data has proved that grain prices in 2006 were not due to biofuel production, but because of high petrol prices, and increased volatility due to commodity index investments. The analysis claims that biofuel production HADA a modest 4-30% contribution in increase of food price up to 2007.In Asia the largest biofuel producers are Indonesia, Philippines, Malaysia, Thailand, China, and India. Globally the amount of water utilized to produce biofuel is modest, water scarcity problems may arise due to irrigation of bioethanol. But only growing countries may face this water scarcity. Algae biofuels avoid drawbacks associated with crop-based biofuels [34]. They aid in creating a greener and sustainable future by encouraging sustainable feedstocks, lowering greenhouse gas emissions, and shifting to cleaner energy sources.

Biofuel used as sustainable energy in India by substituting fossil fuels. Biofuel industry is still in starting stage due to technical issues. 30 barriers to the sustainable development of biofuels were viewed by the literatures. Interpretive Structural Modelling (ISM) and evaluation in laboratory methods established a relation in between challenges to identify the most significant things. These barriers are also involved in using MICMAC analysis. The results appeal that lack of Governmental support, and Lack entrepreneurship support. And lack of biomass standards are the biggest issue . To understand the full potentials of these techniques, collaboration between academic industry and representatives, and policymakers are essential. The utilization of fossils by humans has emerged as a global concern, particularly among the certain industries in the early 20^{th} era commonly referred to as "industrial revolution". Biofuel emerged choice to meet requirements. Investments have been made in research in developed countries. India started biofuel production in 2003.

VIII. ENVIRONMENTAL IMPACTS OF BIOFUELS

Environmental issues include environmentally friendly techniques to increase energy. Air pollution, greenhouse effect, global warming. Biofuel policy promoted the use of transport from biomass as well as renewable fuels [35]. Biofuels are the most reduced CO2 in the transportation industry. However, Due to many fundamental restrictions, such as lack of raw materials, low CO2 , and poor cost competitive things, traditional plant biofuels (e.g., biodiesel, bioethanol) had low transportation-fuel usage in 2015, under 3%. Biofuels provide new economic opportunities for people who live in rural areas such as oil importers and other countries that are developing. The policy of Biofuel concerns job opportunities, greater efficiency in general business and protection of the environment. Projections are important for long term and policy issues.

Renewable energy uses indigenous resources which have the capability to provide energy. Advanced biofuels, such as microalgal, and electro biofuels, mainly those derived from inedible biomass, and positive answer to the problem rising for biofuel demand [36]. Fuels and energy derived from biomass can be capable of alternating fossil-based fuels. Globally, there is need for producing alternative fuels for future energy use and ensure to protect environment. Biofuels are lowering its dependence on petroleum, which is associated with economic vulnerability, and reducing greenhouse gas emissions and pollutants, and increasing economic demand and prices for crop production. Now a days biofuels and bio energy produced from crop residues have shown a greater consideration towards sustainable production. The major factors that affect biofuels are investment towards

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land, feedstocks, techniques and scale. Biofuels also offers economic benefits and reduce emission and secure energy. Feedstock involved in agricultural land will affect food security and cause land pollution, while that replace forest land and cause damage [37].The global leaders in biofuel production have been the US, Brazil, and the European Union. In all three regions, the initial policies were in hand of government However, over time as the level of biofuels production grew, and the burden of subsidy on government budgets increased, all three regions move targets, which shift the cost of the policies towards consumers use.

As we know from cellulose, waste will wash away some of the problems, but comes with risks. In order to ensure benefits of biofuels, governments, researchers need to work together. The greatest benefits may come from feedstocks. The National Academy report on this topic (National Research Council, 2011) provides one of the most important data on environmental impacts of biofuels and the large uncertainty involved in getting standard estimates. Much of recent land is converted into agro-economical of land. This lead to gradual penetration of commercial crops that provide suitable cultivation in developing countries, embraced by producing country governments to achieve energy security and to rural economic development through employment and market integration. Foreign and domestic investment in biofuel feedstock cultivation are expanding in large numbers especially in the industrial economy.

IX. WASTAGE AS BIOFUEL

1. **Potato Peel Waste [PPW]:** Excessively large amounts of PPW is generated from Kitchens and various Potato Processing Industries. Its proper utilization yields various useful products such as bioethanol and biogas which can be used directly or can be mixed with gasoline) [38]. Production of Bio hydrogen is also feasible [39].

2. **Duckweed:** It is a non-food crop in many countries or even if it's a food crop it does not have much demand compared to Wheat, Rice or other vegetables. It has a higher growth rate, starch content and biomass. It can be used for the production of ethyl alcohol, butyl alcohol and biogas [40].

3. **Leather Solid Wastes:** Leather contains high amounts of proteins and fats, which can be used effectively for energy generation [41].

4. **Straw:** It is a Lignocellulosic feedstock which is an agricultural residue including dried leaves, stalks, etc. Used for commercial production of biogas and ethanol. Biobutanol, biodiesel and biochemicals can also be produced.

5. **Fruit Pomace Waste:** Biomethane, bioethanol, biofertilizers, biofuels, biochar, organic acids and enzymes are obtained [43].

6. **Fruit Peel Waste:** It has the potential to pollute air, water and soil if left exposed in the atmosphere. Instead it can be put to commercial use for the generation of ethanol. Cellulose, which is the major component of orange peel, can be changed into β-D-Glucose by the action of genetically engineered enzymes such as Saccharomyces cerevisiae [44].

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7. **Waste Paper:** Have high content of carbohydrates. It is an efficient feedstock for bioethanol production. Has the highest yield. A wet blending step prior to enzymatic hydrolysis increases the sugar yield by about 10% [45].

8. **Discarded Animal Fats[DAFs]:** They contain Triglycerides which are the main constituents of Biodiesel [46].

9. **Wood and Agricultural Residues:** Wood waste includes discarded logs, sawdust, wood chips, wood pellets etc. produced from mills and factories. To give an example, the wood chips and sawdust produced from various wood processing industries can be used as boiler fuels and feedstock for the manufacturing of ethanol [47].The waste residues produced from direct agricultural production at the field are mostly crop residues like leaves, stovers, straws, and seed pods, etc. Agricultural residues generated from crop residues are the most abundant and cheapest organic wastes. Most widely used 3 major crop residues are : rice straw, wheat straw and corn stover. [48].

10. **Agro-Industry Wastes:** Includes biomass from food industries such as pomace of fruits,skin and shells of fruits and vegetables, starch residues etc. and also wastes from non food- based industries such as Jatropha Curcas [48].

11. **Waste Cooking Oils:** Used oils or waste oils when treated to remove H2O and undesired solid fragments can be converted to biodiesel by using techniques such as filtration, heating and transesterification. Biodiesel manufacturing cost can be reduced significantly [49]. As the oil is being used repeatedly even after cooking it can be disposed properly [47].

12. **Vegetable Wastes:** It is a dynamic decomposable feedstock. These wastes include rotten, shells, peels or slurries. These wastes are utilized for manufacturing biofuels through fermentation. [50].

13. **Animal Dung:** Includes chicken manure, sheep manure, cow manure, Buffalo manure, goat manure and manure from pig and other cattle.With the increase in meat consumption, poultry and dairy farming, the waste generated would be very huge. The waste management can be done easily by full utilization and exploitation of animal manure as a promising feedstock.

14. **Used Cooking Oils and Grease:** Biofuels are produced by the method of Transesterification. Fats and Oils get converted into Glycerin and biodiesel.

15. **Food Waste:** The following technologies can be applied for the production of various fuels such as biohydrogen, biogas, biomethane,bioethanol, biodiesel,bioalcohols and bioethers. They are as follows:Anaerobic digestion, aerobic digestion, microbial fermentation process,pyrolysis, transesterification etc. Food waste includes lignocellulosic materials such as Jatropha, Cassava, Switchgrass, straw and various biomass residues [51].

16. **Wastewater Sludge or Municipal Solid Waste:** With increasing demand for fossil fuels there is a high risk of their depletion in the future. Therefore, the need to

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create sustainable biofuels arises.Increased usage of fossil fuel leads to deterioration of air , soil and water quality which significantly impacts human health and wellbeing. Anaerobic digestion and fermentation processes are the most frequently used methods for the generation of biogas and bioethanol from municipal solid waste with its proper utilization [52].

X. CONCLUSION

To sum up, biofuels are an important part of the global shift towards more sustainable energy. They provide several advantages, including decrease in air pollution, minimal reliance on fossil fuels and the potential for economic growth. However, challenges remain, including resource competition, land use issues and the need for cost-effective and efficient production processes. As technology and research progresses, addressing these issues will be crucial to unlock the biofuel production that contributes to a cleaner and greener energy future. There is no doubt that biofuels – in their various generations – contribute significantly in the wider context of renewable power.

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