

# Second Generation Biofuel – An Alternative Clean Fuel

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**Abstract:** Renewable energy resources are in high demand to decrease dependence on fossil fuels and mitigate greenhouse gas emissions. Biofuel industries, particularly bioethanol and biodiesel, have been rapidly increasing in tandem with agricultural production over more than a decade. First-generation biofuel manufacturing is heavily reliant on agriculture food sources like maize, sugarcane, sugar beets, soybeans, and canola. As a result, the intrinsic competitiveness among foods and fuels has been a point of contention in community for the past couple of years. Existing technological advancements in research and innovation have paved the way for the manufacturing of next-generation biofuels from a variety of feedstock's, including agricultural waste materials, crops remnants and cellulosic biomass from high-yielding trees and bushes varieties. This report discusses the existing state of second-generation biofuel manufacturing as well as the feedstock utilized in fuel production, biofuel production globally and the current situation in India. This study also explores the current advancements in the findings and advancement of second-generation biofuel extraction from various feedstock's. The forthcoming directions of agriculture and energy industrial sectors has also been addressed in order to feed the world 's growing population and to fuel the world's most energy-intensive industry, transportation.

**Keywords:** Renewable Energy, Automobiles, Biodiesel, Biomass.

## I. INTRODUCTION

Solid, liquid, or gaseous biofuels are sources of energy obtained from organic materials. There are two types of biofuels: primary and secondary. Secondary biofuels including the bioethanol and biodiesel are developed by exploiting biomass and could be utilized in automobiles and numerous industrialized procedures. While primary biofuels like wood residues are utilized in a raw state mainly for heat generation, preparing food, or power generation, secondary biofuels including bioethanol and biodiesel are manufactured

by processed biomass and can be utilized in automobiles and different industrial operations. The utilization of non-renewable resources for automotive fuels and petrochemicals is the foundation of contemporary world. The financial condition and development of emerging nations all over the world are determined by resources of energy and their application [1]. The worldwide requirement for energy is increasing as the world's population increases and industrial growth rises. Traditional fossil fuels like oil, coal, and natural gas continue to be the primary sources of energy. The persistent usage of fossil fuels has significantly increased the emissions of greenhouse gasses in the earth's atmosphere [2]. Diminishing fossil fuel stocks and rising energy consumption, along with environmental problems, have prompted intensive investigation towards the development of environmentally sustainable, biodegradable, and cost-effective alternative energy sources.

The utilization of sustainable materials to generate liquid biofuels offers appealing approaches for lowering greenhouse gas emissions, reducing dependence on crude oil, solving energy security issues, reinforcing rural and agribusiness economies, and ensuring the global transportation system's long-term viability [3]. Bioethanol is a leading global renewable transportation biofuel that could easily replace fossil fuels. Bioethanol has traditionally been derived from sucrose and starch-rich fuel sources, referred as first-generation bioethanol; although, this substance is incompatible with the production of food and feed. As an alternate to first-generation bioethanol, a cellulosic bioethanol principle based on lignocellulosic biomass from crop production and by-products is presently being developed. Lignocellulosic substances are low-cost renewable commodities that are plentiful [4]. The most plentiful worldwide resource of sustainable biomass is

lignocellulosic waste substances derived from energy crops, woody biomass and agriculture waste [5]. In aspects of pre-treatment of the organic matter to disintegrate its components, break-down of cellulose and hemicellulose into hexose and pentose sugars, effective transformation of lignocellulosic biomass into bioethanol continues to be a significant study area. The entire transformation procedures of lignocellulosic waste into bio-ethanol, as well as the economics and environmental aspects of bioethanol extraction from lignocellulosic waste, are described in this review. The leading nations in biofuel production in 2019 are depicted in figure 1. The same year, Germany's production totaled approximately 143 petajoules. As a result, Germany is one of the five largest biofuel producers in the world, and the largest manufacturer in Europe.

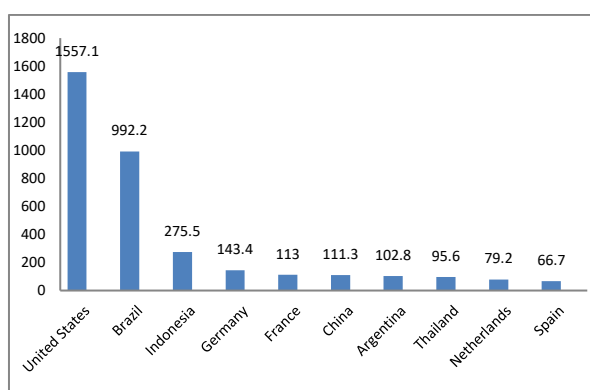


Fig1. Leading countries based on biofuel production in 2019 (in petajoules), source: statista.com

## II. FIRST GENERATION VS SECOND GENERATION

Currently, most bioethanol manufacturing operations use more easily degradable biomass feedstock's like cereal crops and sugarcane juices. Moreover, using eatable agricultural products solely for biofuel manufacturing is incompatible with the development of food and feed [6]. Bioethanol made from sucrose and starch-containing sources of energy is categorized as first generation bioethanol and bioethanol made from cellulosic feedstock is categorized as second generation bioethanol [7]. Lignocellulosic biomass is a useful source of energy for bioethanol manufacturing which is also environmentally friendly. Biomass is a potential feedstock for chemical manufacturing as well as a source of energy [8]. Second-generation biofuels are made from lignocellulosic materials, which is the woody portion of vegetation that does not associated with food manufacturing.

Agricultural remnants, forest harvested by-products or wood processed debris including leaves, straw, or wood chips, and also non-edible corn or sugarcane elements, are all potential resources [9]. As a result, third-generation biofuels extracted from microalgae are regarded as viable alternate energy

resources that eliminate the main disadvantages of first- and second-generation biofuels [10]. On the basis of area, microalgae can generate 15–300 times more fuel for producing biodiesel than conventional crops. Microalgae are algae types that are good for producing lipids. The macro algae or seaweed, on the other side, have a variety of industrial uses but are not used to produce lipids. Algae have other industrial applications, including the production of omega-3 fatty acids, fertilizer, chemical feedstock, medical products and biopolymers. Diatoms, green algae, golden-brown algae, and blue-green algae are all kinds of microalgae [11].

## III. CURRENT STATUS IN INDIA

India is becoming more interested in using ethanol as a vehicle fuel. Breweries in India have made a significant contribution. They're using the leftover alcohol in gasoline as a mixing additive or an oxygenate. The Society for Indian Automobile Manufacturers has now verified that cars contain 5% ethanol doped gasoline. The potential to generate ethanol was also reported by state governments of prominent sugar-producing areas and officials of the sugar/distillery industrial sectors. In 2006, ethanol need was 0.64 billion litres at 5% gasoline doping concentration, whereas 10 percent mixing of all gasoline sold in India would need around 1.5 billion litres [12]. In 2017, this requirement is expected to reach 2.2 billion litres. The Indian alcohol industry is well-established, with 295 distilleries across the nation producing 3.2 billion litres of alcohol annually. In 2019, India's nameplate capacity for biodiesel manufacturing was 670 million litres, according to figure 2. Under ordinary operational circumstances the nameplate capacity is the amount of biodiesel that can be generated over a 12-month period.

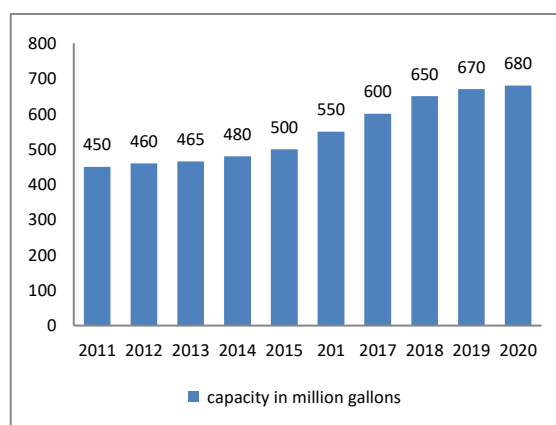


Fig2. Capacity of biodiesel in India from 2011 to 2020, source: statista.com

IV. SECOND-GENERATION BIOFUELS

'Second-generation biofuels are manufactured from lignocellulosic biomass feedstock utilizing technologically advanced techniques,' as per a UN report on biofuels [13]. The objective of second-generation biofuels is to increase the quantity of biofuel that could be manufactured sustainably by utilizing biomass made up of non-food components of existing crops, as well as many other non-food crops, and also municipal, commercial, and construction residues. Second-generation biofuels are believed to reduce net carbon emissions, improve energy efficiency, and decrease energy dependence, possibly outperforming first-generation biofuels. Even though it is beyond the reach of this article, research on third-generation and fourth-generation biofuels is also underway [14]. Expenditure, technological advancements, and infrastructure requirements are among the difficulties. Second-generation biofuels cannot still be manufactured commercially on a massive scale due to comparatively higher manufacturing costs. In attempt to render operations more cost- and energy-efficient, important advancements in enzymes, pre-treatment, and fermentation are also required. The construction of a new infrastructure for extracting, exporting, preserving, and processing biomass would be required for the commercial exploitation of second-generation biofuels.

For the biofuel business sector to achieve success, biomass feedstock must be accessible at a lower price and on a massive scale, allowing it to make a significant contribution to energy and environmental issues. Production of cellulosic crops, including short rotation coppices, winter cover crops, or perennial grasses, is highly regarded as having significantly more favourable environmental characteristics than corn, soy, or other yearly row crops [15]. Several biomass feedstock's, like solid trash including green waste, food waste, and biodegradable fragments of municipal solid waste (MSW), will benefit the biofuel industrial sector [16]. The primary elements of these lignocellulose substances are cellulose and polymeric hemicelluloses, and their bioconversion involves a pre-treatment process [17, 18]. Physical, chemical, and enzymatic approaches as well as a confluence of these approaches could be used to pre-treat and hydrolyze lignocelluloses.

				inophyllum
bamboo	Citrus waste	Food waste	Switchgrass	Corn oil
Energy maize	Corn stover	Municipal solid waste	Willow	Castor bean
Eucalyptus	Green waste	Olive pulp		Cottonseed
Grass	Industrial waste	Recycled cooking oil		Jatropha
Miscanthus	Sugarcane bagasse	Waste water from pulp and paper industry		Palm
Oilseed rape	sawdust	Waste water from sugar factory		Pogamia pinnata
poplar	Wheat straw			Rapeseed
Salix	Waste rice straw			Soybean
Sugarbeet	wood			Sunflower
Sweet sorghum	Wood chips			
Switchgrass				
Willow				
Winter triticale				
Winter wheat				
wood				

Table 1. Selected second-generation biomass feedstocks.

V. BIOMASS FEEDSTOCK

The use of biomass as a feedstock for second-generation biofuel manufacturing is still an issue. Agricultural residues are being used to produce the next generation of feedstock, but some other biomass feedstock's are also being considered (Table 1). Biodegradable waste disposal tactics, energy and climate change, fiscal incentives, possible future businesses for by-products, and planning and land usage are all factors that could play a significant role in waste to energy. Public perception, inefficient heat utilization, regulatory constraints, and a shortage of appropriately trained employees to design, construct and then run waste to energy plants, are all the obstacles.

A. Energy Crops

Herbaceous energy crops and short-rotation coppice are the two kinds of energy crops (SRC). SRCs are species that were being cultivated for production of fiber for the pulp manufacturers and more recently, for growing biomass for

Energy crops	Agricultural and wood residues	Organic waste	Traditional breeding and genetically modified crops	Vegetable oils
Amaranth	Bam	Animal fat	Miscanthus	Calophyllum

energy requirements [19]. Herbaceous energy crops are mostly varieties of grasses that can be collected as hay or fresh, while SRCs are species which are being cultivated for generating fiber for the pulp industrial sectors and, most recently, for generating biomass for energy requirements.

#### *B. Agricultural And Wood Residues*

the utilization of agricultural and forest remnants might lead to reduce overall cost in the biofuel processing. In comparison to the expense of manufacturing a tonne of particularly grown energy crops, where resources should be invested to grow, fertilize, and harvesting them. Agricultural wastes like bagasse and remnants from cereal production, like corn, wheat, barley, rice, and rye, are examples of feedstocks that could be utilized to produce bioethanol. Moreover, after recognizing for requirements like soil conservation, livestock feed, and seasonal variation, only about 15% of overall remnant production will be accessible for energy production [20]. Agricultural wastes might become a more crucial biofuel feedstock as bioenergy generation rises and better management techniques might enhance their accessibility.

#### *C. Organic Waste*

Organic residue from the paper industries, animal fats and byproducts, reprocessed cooking oils, and a variety of several other sources of energy are underutilized. In addition, MSW is a valuable provider of biomass for the manufacturing of biofuels [21]. Paper/card, food scraps, garden garbage, textiles, fines, and various other things make up the majority of unprocessed MSW in the EU. Furthermore, approximately 80% of MSW might be biodegradable to some extent, with 65 percent biodegradability in an average [21]. MSW contains a biodegradable component that could be used as a sustainable biofuel resource [22]. Converting waste products to biofuel has less effects on the environment than growing energy crops, so using MSW to make biofuel could be beneficial. Furthermore, by reducing debris transfers to garbage dumps, MSW conversions would conserve even more space, and very little resources expenditure would be needed aside from MSW gathering and segregation. As a result, one of the key drivers for highly developed waste to energy processing sites is that they function on a smaller scale, requiring less land and having a lower overall carbon footprint. They could be used by industries to process garbage on-site, utilize the energy for their processes, and supply any surplus energy to the grid. These might even be extremely easy to obtain planning approval because they are more expected to be located in established industrialized regions and need lesser automobile movements, reducing

traffic and amenity concerns. Bioethanol is made from potato peelings from chips plants in Northern Ireland, for instance, which have also been recognized as a promising source of fuel [23].

#### *D. Traditional Breeding And Genetically Modified Crops*

Additional alternative is to utilize genetically modified crops (GMC), which can enhance total power generation of industry in a variety of manner including: (i) increasing solar energy conversion by modifying photosynthetic pathways; (ii) enhancing protection against pest and diseases; (iii) water shortage resistance to adapt energy crop plants to the impacts of climate change and (iv) cold resistance to adapt energy crops to the impacts of cold climate; (v) cultivation in marginal lands like saline or contaminated land to address environmental issues and achieve a profitable activity; (vi) lowering of management power requirements like tilling, harvesting, and transport; (vii) significant decrease of fertilizer implementation through utilizing engineered plant for Nitrogen fixation or enhancing mineral capitation efficiency; (viii) alterations of lignin composition can also enhance the biomass conversion to biofuels; (ix) multiproduct generation for instance, the cellulase generation by maize which might decrease the price of costly enzymes for the biofuel transformation of cellulose [23]. Some of these can be obtained by conventional breeding at lesser cost, but need longer periods of time.

#### *E. Vegetable Oils*

Vegetable oils, which are obtained from oil seeds, crops, nuts, fruits, and leaves, could be utilized as diesel engine fuels, but they are comparatively costly if cultivated as specialized energy crops. As first-generation biofuels, shrubs bearing oilseeds like *Jatropha*, castor bean, *Pogamia Pinnata*, and *Calophyllum inophyllum* have been utilized. Despite the fact that there are quite limited details accessible about this perennial shrub and its oil-bearing seed plant, *Jatropha* might be the most widely employed oilseed crop [24]. *Jatropha* can be cultivated in the most remote locations, but high yields can only be achieved on fertile soils or with the addition of water and fertilizers. Castor bean was first adopted more than half a century ago for usage in special lubricants and polymers, and now it is being gradually introduced as a biodiesel crop, particularly in Brazil. *Pogamia Pinnata* and *Calophyllum inophyllum* are two other perennial shrubs with high oil composition seeds that are being accepted, particularly in India [25]. Rapeseed oil methyl ester (RME), made from the oilseed rape, is the most common replacement fuel in Europe, while soybean oil is being utilized in the

United States and canola oil is utilized in Canada. For instance *Calophyllum inophyllum* yields nearly twice as much oil per hectare as *Jatropha* [25]. Even though oilseeds discussed above may contribute to second-generation biofuels, but several issues must be addressed before a full-scale industry could be created. Most of the mentioned crops are still grown by hand and have not yet been inhabited to the level of personal protection [25]. Future studies must focus on domesticating oilseed-bearing shrubs in order to maximize the harvest index, make mechanical harvesting easier and reduce harmful matter production, so that they can be utilized as a second-generation biomass feedstock.

#### F. TECHNOLOGY

The excessive expense of extraction instead of the expense or accessibility of feedstock is currently hampering the growth of a massive industry transforming lignocellulosic biomass into liquid fuels [26]. Second-generation biofuel development approaches are far more complicated than first-generation biofuel development operations and both systems and logistics are still in their infancy. Although organic oils are harvested from vegetation to manufacture fuel in first-generation biofuels, second-generation methods, which work with trash and 'woody' substances, necessitate complicated catalysis and chemical modification methods to generate the oils in the first place [13]. Thermochemical conversion, biochemical conversion, and vegetable oil retrieval have all been developed new methods for using second-generation biomass feedstock for producing energy. Incineration uses a number of technologies, such as pile burners, stocker combustors, and fluidized-bed combustors. Gasification is the process of converting biomass into a gaseous fuel by partially oxidizing it. Pyrolysis is the thermal detrimental distillation of biomass in the complete lack of oxygen at nearly 5000°C, yielding charcoal. For the manufacturing of charcoal, traditional gradual pyrolysis is widely used with a wide range of conversion efficiency. Liquefaction is a catalyst-assisted low-temperature, high-pressure thermochemical processes. Hydrothermal improvements converts biomass to biocrude in water at higher pressure and mild temperatures and it is still in the pre-pilot-plant stage.

Some other option is to establish a technique or processes that can transform carbon-based feedstock into hydrogen and carbon monoxide, as well as the residual elements. This might convert coal or natural gas into liquid fuels by integrating microbes that convert synthesis gas (syngas) into ethanol. Fermentation is an anaerobic phenomenon wherein yeast transforms sugars like glucose, fructose, and sucrose into ethanol and carbon dioxide under anaerobic conditions. Extracellular enzymes hydrolyze organic compounds like polysaccharides, proteins, and fat in the anaerobic digestion

method, an acidification stage wherein the hydrolysis components are transformed into H<sub>2</sub>, formate, acetate, and relatively high molecular weight volatile fatty acids; and a third stage in which biogas, a combination of CO<sub>2</sub> and methane, is generated. Mixed microbiological groups finish the methanogenic transition, yielding CH<sub>4</sub> as the only reduced organic compound. On an industrial level, mainly bioethanol and biodiesel are currently manufactured as fuels. These fuels, which include ethyltertio-butyl-ether (ETBE), which is partly manufactured with bioethanol, account for more than 90% of the biofuel market [27].

#### G. PRODUCTION OF BIOETHANOL

Bioethanol can be made from lignocellulosic feedstock using a variety of techniques, many of which are presently being utilized by businesses. The simplest and most effective method of producing bioethanol is through yeast fermentation of free sugars [27]. Although enzyme hydrolysis proceeded by yeast fermentation has a lower efficiency, it could be used with a variety of substrate feedstocks, which might be essential for large-scale bioethanol manufacturing [16, 28]. It is also feasible to make bioethanol from syngas fermentation [27]. Method studies have been identified in order to identify quite particular technological benefits for lowering bioethanol manufacturing costs and estimating the price of manufacturing. The advancement of pre-treatment techniques and genetically engineered organisms utilizing agriculture waste and forest species has been the priority of prior bioethanol researchers [30]. Other research has looked into the viability of producing bioethanol from paper trash and garden wastes [31]. Despite this, there is little data on the utilization of MSW as a wasted biomass for bioethanol manufacturing [16]. MSW feedstock is expected to become even more economically desirable as a result of its lower cost and plentiful supply, therefore further exploration is needed to improve bioethanol processes and techniques for the transformation of MSW to bioethanol production.

The pre-hydrolysis treatments and enzymatic hydrolysis of MSW are critical steps in the biomass transformation of MSW to bioethanol, and their refinement will result in more environmentally friendly and cost-effective approaches [30,32]. Physical, physicochemical, chemical, and biological pre-treatment procedures have been used to improve the enzymatic digestibility of many cellulosic substances [33]. It is possible to make bioethanol utilizing a mixture of dilute strong acid and steam treatments utilizing various constituents of MSW [16, 34]. Figure 3 shows the global fuel ethanol manufacturing in million gallons by nations in 2020. The United States generated the most fuel ethanol in the world in 2020, producing a total of 13.8 billion gallons.

Brazil came in second with about 7.9 billion gallons. Ethanol is a grain alcohol that could be utilized in automobiles when mixed with gasoline.

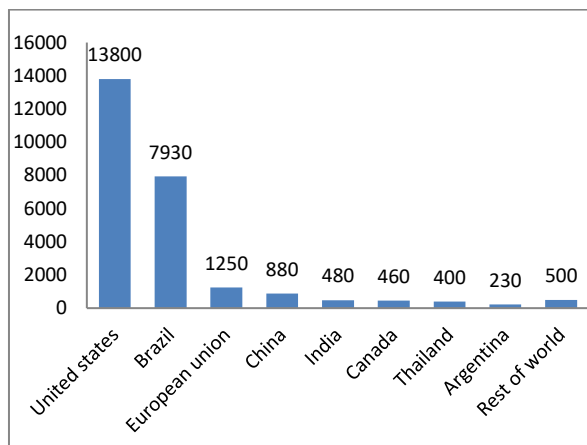


Fig 3. Fuel ethanol production worldwide in 2020 by country (in million gallons), source: statista.com

#### H. PRODUCTION OF BIODIESEL

Biodiesel is a monoalkyl ester of fatty acids obtained from vegetable oil that is currently manufactured using petrochemically derived methanol and a catalyst [27]. Other methods of refining vegetable oils and fats for usage as biodiesel have also been taken into consideration, including pyrolysis, dilution with hydrocarbons, and emulsification. To make biodiesel, a non-catalytic supercritical methanol technique has been established that enables for a quick processing and higher yielding due to concurrent trans esterification of triglycerides and methyl esterification of fatty acids, which needs less reaction time and energy utilization [35,36]. The microbiology of biodiesel deterioration is currently a topic of major worry due to bacterial oxidation throughout storing and the inevitable moisture content, which causes corrosion issues. Moreover, in several places, the glycerol generated throughout trans esterification causes a deposition issue [27]. Micro diesel might still be a future fuel made entirely from engineered *Escherichia coli*. Nonetheless, microbial contributions to biodiesel manufacturing are currently nearly non-existent, and the usage of biological system enzymes in trans esterification is still yet to be established [27].

#### I. PRODUCTION OF BIOBUTANOL

Higher alcohols, in comparison to the conventional biofuel ethanol, might have benefits as gasoline alternatives due to their relatively high energy density, lesser hygroscopicity, and lower volatility [37]. Microbes, like *Clostridium acetobutylicum*, have been considered to ferment sugar to generate butanol, acetone, and ethanol since 1916 – the ABE process, which was primarily used for acetone throughout

WWI. Acetone was manufactured in this method along with butanol and ethanol, despite the fact that butanol gained hardly any worth at that time [38]. However, by the 1980s, microbial breweries had been abandoned in favor of a less expensive petrochemical path involving the reaction of carbon monoxide and hydrogen with propylene [39]. Biobutanol, on the other hand, has been in absolutely constant manufacturing since 1916, mostly as an aqueous solution and a common chemical. Currently, newer applications for biobutanol are arising, such as as a diesel and kerosene substitute, and bacterial butanol fermentation is gaining popularity [30]. The primary issue however is that the bacteria are harmed by the butanol they produce when it reaches a concentration of about 2%. The butanol metabolic pathway's recombinant gene technology could be utilized to solve this problem.

#### J. PRODUCTION OF BIOGAS

The procedure of anaerobic digestion of biomass leads to the cost-effective synthesis of biogas. In traditional anaerobic digesters or two-phase anaerobic fermentation, biogas has been manufactured widely using animal wastes, wastewater sludge, and the organic waste component of MSW. Anaerobic digestion, for instance, is utilized to regulate sewage sludge while also converting a portion of the volatile compounds into biogas. Presently, anaerobic digestion of sewage sludge is primarily used in larger and moderate sized wastewater treatment plants and more focus is observed on small-scale plants. Manure is an easily obtainable material on several farmlands, but it has a low producing rate and yields of biogas, as well as a higher investing cost, making biogas generation from compost economically unviable [40]. Thus, adding energy-rich co-substrates to the anaerobic digester would significantly increase biogas generation resulting in improved financial and environmental situations [41].

#### K. PRODUCTION OF BIOHYDROGEN

Pyrolysis, gasification, steam gasification, steam reforming of bio-oils, and enzymatic decomposition of sugars could all generate hydrogen from biomass [35], but the productivity is low, at 16–18 percent depending on dried biomass weight [42]. Fermentative H<sub>2</sub> generation has been proposed as a new component of anaerobic digestion, with two main biological operations for bio hydrogen extraction is proposed. Dark fermentation, for example, is a kind of anaerobic digestion that involves primarily hydrolysis and acid genesis and produces H<sub>2</sub>, CO<sub>2</sub>, and a few basic organic compounds. Light-driven procedures are used by another method for producing H<sub>2</sub>. Direct bio photolysis employs solar energy to transform water to oxygen and hydrogen, while indirect bio

photolysis separates the formation of oxygen and hydrogen in time and space. Photosynthetic bacteria use their nitrogenase system to make H<sub>2</sub> throughout photo fermentation [43]. One acidogenic reactor and one methanogenic reactor are typically used in fermentative hydrogen production systems. Because only a small percentage of biomass feedstock is converted to hydrogen (5–10%) therefore the second stage uses the leftover organic matter [43]. CSTRs (completely stirred tank reactors) are commonly utilized because of their ease of construction and operations [44]. Furthermore, biomass immobilization is commonly utilized for hydrogen-producing microorganisms, like UASB (upflow anaerobic sludge blanket) [45].

#### L. BIOREFINERY

Bio refinery is the long-term conversion of biomass into a variety of commercially viable goods [46]. Bio refineries are still in the early stages of development, and their products might find alternative usage as food, chemicals and fuels. Nova Mont, for instance, has created new polymeric completing compounds extracted from vegetable oils, as well as a low-impact path to completing agents for starch, and it may expand beyond bio plastics to the field of renewable chemical intermediates, resulting in a completely integrated bio refinery [46]. Despite the growing focus on utilizing vegetation matter as the foundation for specific products, feedstock security for so-called sustainable primary resources continues to be a significant concern for large corporations. Pulp and paper mills that could make bioethanol from forestry materials are the finest representation of bio refineries nowadays. These could grow into large-scale chemical plants or local biofuel stations.

#### M. CONCLUSION

The possibilities for second-generation biofuels to solve several of the issues that are related to the current industry has just starting to be recognized. In terms of feedstock or manufacturing processes, there are no straightforward clear-cut transitions from first- to second-generation biofuels. Many conventional techniques, including sugarcane fermentation, will remain economically viable for several years. Conventional feedstock improvements are expected to alter the cost effectiveness and carbon footprint of crops like corn. However, in several nations, ethanol has become a controversial topic. Big multinational companies in industrial sectors in the range from agribusiness to oil are largely getting involved in the biofuels industry, but the problems are complicated. The solutions are expected to originate from a combination of smaller businesses with innovative technology and established players. Only then it will be practically possible to partially replace fossil fuels

with second-generation biofuels. It is necessary to not overlook the capability of biofuel to make a contribution to the solutions of energy and climate change problems.

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