Biofuel Vehicles

Subjects: Engineering, Mechanical
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Biofuels and bioenergy are produced by processing biomass, or organic matter, from plants, crops, and their waste products. Biofuel can displace fuels made from petroleum because it comes from renewable sources. The only alternative energy source that can provide liquid fuels to take the place of fossil fuels is bioenergy. Biofuels are a viable alternative to meet future demand while reducing greenhouse gas emissions and environmental effects.

Keywords: sustainable vehicles ; fuel cell electric vehicles ; biofuel vehicles

1. Introduction

A total of 80% of the world's primary energy comes from fossil fuels, of which the transportation sector uses a large amount [1]. Approximately 10% of the world's primary energy supply is made up of bioenergy. Bioenergy is expected to play a bigger part in modern bioenergy than traditional biomass utilization, leading to a projected 145 EJ rise in production by 2060 from the current level of 56 [2]. Large-scale energy generation is often proposed using a variety of bioenergy feedstocks, such as algae, crops, and lignocellulosic biomass. The potential for usage as biofuel energy resources includes a variety of vegetation, including wood, plants, grass/herbal plants, and other crops, including oleaginous seeds and sugar crops with high starch contents [3]. Because biofuels are produced from natural feedstocks, they are a more globally distributed form of renewable alternatives than fossil fuels. Biofuels and bioenergy are produced by processing biomass, or organic matter, from plants, crops, and their waste products. Biofuel can displace fuels made from petroleum because it comes from renewable sources. The only alternative energy source that can provide liquid fuels to take the place of fossil fuels is bioenergy. Biofuels are a viable alternative to meet future demand while reducing greenhouse gas emissions and environmental effects [4]. Biomass is an organic material that comes from a variety of sources, including grasses, trees, flowers and stems. It is not formed from fossils. It is a feasible substitute energy source because of its innate chemical energy. It is anticipated that by 2050, biomass will account for almost two-thirds of all direct renewable energy sources [5]. Since developing nations frequently experience extreme energy insecurity and have thriving agricultural sectors that can support the production of biofuels from energy crops, using biofuels as a mode of transportation presents a great opportunity. The increasing use of internal-combustion engines and the resulting high demand for petroleum-based fuels have negative effects on the environment, human health, and global warming. By lowering emissions from cars that run on biofuels, the development of biofuels promises to significantly improve air quality. Several developing nations have already started to produce and use biofuels for local transportation needs [6].

2. History and Development

Plant and seed oils have been used since 1500 BCE, and in the middle of the 1800s, they were used as fuel for combustion engines. Engines that ran on pure oil, blends of plant oils and petroleum, or other fuel mixtures were created by inventors like Diesel and Otto. Diesel's oil-powered 10-iron cylinder with a flywheel at the base was the first car to run on biofuel. Nicolas Otto gave a demonstration of the peanut oil-powered engine that was on display at the World Expo. August 10 is recognized as International Biodiesel Day, the day Rudolf Diesel used SVO to demonstrate his internal-combustion engine [7][8]. Vegetable oil transesterification was first identified in the middle of the 19th century, but it took another 50 years for people to recognize the fuel's potential. Before World War II, biodiesel and pure vegetable oil were in use, and the 20th century's energy crises spurred a global rush to produce these fuels. The petroleum industry has dominated the automotive sector for many years because it can produce fuels at a significantly lower cost than fuels derived from biomass. The use of petroleum fuels has led to a century's worth of increased pollution and carbon emissions [9]. The development of infrastructure, research, and technology for biomass-based fuels like biodiesel was hindered by this monopoly. Henry Ford, an American automobile entrepreneur, created the "soybean car" in 1941 and had an interest in alternate fuels. Ford produced one experimental soybean car during World War II, but it was never put on the assembly line because of the conflict [8][10]. **Figure 1** shows the history and timeline of biofuels from the 19th century to 2030.

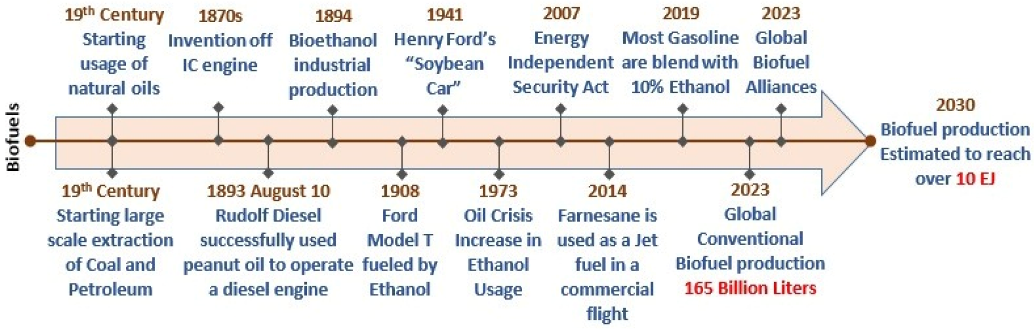

Figure 1. The history and timeline of biofuels.

3. Classification of Biofuels

Over 70% of all petroleum fuel usage is accounted for by the transportation industry. It is predicted that the globe will experience a petroleum oil scarcity by 2070–2080 as a result of the notable growth in petroleum consumption. Because of the greenhouse gas emissions caused by the overuse of petroleum, worries about health and global warming have been raised. By 2040, it is anticipated that greenhouse gas emissions will total about 43 billion metric tons. For this reason, more readily available, easily renewable power sources are necessary. Because they come from renewable sources, are non-toxic, sulfur-free, and biodegradable, biofuels are being developed to replace petroleum. Biofuels are divided into five generations including zero-, first-, second-, third-, and fourth-generation biofuels [11], depending on the feedstock. The classifications of biofuels is shown in **Figure 2**. Natural oils that were obtained straight from nature and used as biofuels are known as zero-generation biofuels. First-generation biofuels are made from plants based on oil, sugar, and starch yields. Genetically modified yields have been developed ever since they were first introduced in 1996–1997. Generally speaking, first-generation liquid biofuels are produced on a large scale using conventional and well-established technology. Ethanol derived from sugar and starch, biodiesel derived from oil crops and hydrogen derived from renewable source are considered as alternative fuels [12]. The first generation of biofuels sparked a controversy about fuel or nutrition; however, the second-generation biofuel made from sustainable lignocellulosic biomass minimizes issues with food safety [13]. Second-generation biofuels are made primarily from agricultural and forest leftovers and came from non-food yields [9]. Advanced biofuel forms are generally derived from biomass that is not food, such as grass, switchgrass, jatropha, and a range of other non-food crops, as well as the stem, leaves, and husks that remain after agricultural production is harvested [14]. Nonetheless, it is commonly known that expensive and advanced technology is needed to extract second-generation biofuels. Moreover, a number of obstacles, such as the need for expensive enzymes, impede the commercialization of second-generation biofuels [15][16][17]. The creation of lignocellulosic biofuels contributes to the alleviation of food and environmental crises. Algal-derived third-generation biofuels are highly recognized, easily refined, and able to be generated on a massive scale while absorbing CO_2. Using microalgae and microbes, the third generation of biofuels creates liquid biofuels such as biodiesel [18][19]. Algae can be grown in many different types of habitats, including marginal farmland, the ocean, barren drylands, and wastewater. Additionally, they do not compete with food crops in watery environments or on agricultural land. Additionally, a variety of genetically engineered microalgae are being produced, and they exhibit great promise for the production of biofuel. According to Abdullah [20] and Patel [21], biofuel generated through genetic engineering of microalgae is referred to as "fourth-generation biofuel". In the progression of biofuel technologies, fourth-generation biofuels represent a sophisticated stage that seeks to address some of the drawbacks of previous generations. Fourth-generation biofuels concentrate on using advanced feedstock and cutting-edge production techniques, in contrast to first-generation biofuels, which are made from food crops, and second-generation biofuels, which are made from non-food crops and trash. Engineered cyanobacterial development is a novel and quickly developing field that is used in the fourth generation of biofuels [11]. This classification highlights the industry's continuous attempts to develop cleaner, more efficient, and economically viable alternatives to conventional fossil fuels, underscoring the dynamic growth of biofuel technologies. The term "bioenergy" describes the secondary energy produced from biomass, such as power production, biomass briquette fuel, bioethanol, biogas, biodiesel, and biohydrogen.

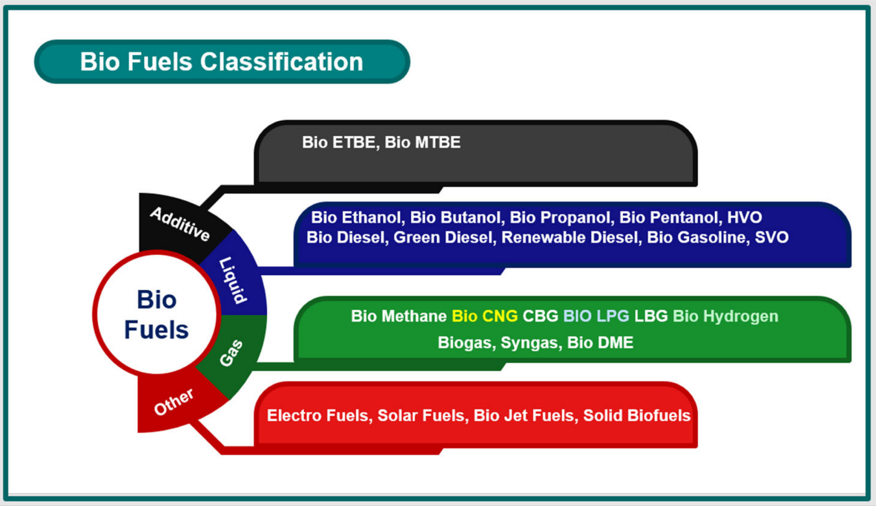

Figure 2. Classification of biofuels.

Unlike fossil fuels, which are formed by extremely slow natural processes, biofuel is a fuel that is created quickly from biomass. An example of this is oil. Biofuels, a broad class of fuels derived from biological sources, are an essential part of the renewable energy landscape. Based on their manufacturing methods and feedstock, these environmentally friendly substitutes for conventional fossil fuels are divided into many generations [22]. Biofuels can also be divided into the liquid, gas, and solid categories according to their physical states. Because of its carbon-based structural makeup and ability to be converted straight into liquid fuel, biomass is now regarded as the most potential renewable energy source that can contribute to the world's long-term energy supply. Liquid and gaseous biofuels derived from fossil fuels come in a range of forms that can be used in different kinds of vehicles [23]. As substitutes for goods derived from petroleum, biodiesel and hydrogenated vegetable oils (HVOs) have recently gained popularity [24][25].

The global switch to sustainable and renewable energy from a variety of sources is greatly aided by liquid biofuels. These comprise a range of forestry residues, agricultural materials related to food crops, including non-food energy crops like eucalyptus and switch grass, solid biogenic waste, etc. With a large amount of feedstock accessible, these emerging choices can create biofuel for transportation with minimum or maximum risk dependent on sustainability, which is associated with any changes in land utilization as well as competition over food production. Between 2015 and 2045, liquid biofuels offer a more expansive view, with a variety of technological features for advanced biofuels, particularly liquid transport fuels for usage in transportation, shipping, and aviation. According to the International Renewable Energy Agency (IRENA), by 2030, 10% of the energy used in the transportation sector will come from liquid biofuels, which comprise biodiesel and both conventional and advanced forms of ethanol [26]. Because of its remarkable properties, including a higher cetane number, a remarkable heat for vaporization, and sustainability, bioethanol is recognized as a superior substitute for fossil fuels like petrol and diesel [27][28]. Because bioethanol and petrol are similar, using them does not necessitate significant engine modifications. Its pure form is soluble in water, ether, acetone, benzene, and some other organic solvents, making its low-cost manufacture more feasible. In the next 20 years, it is anticipated to overtake all other biofuels as the most popular one for the world's transport sectors in the next 20 years. Bioethanol has the ability to be used in its pure form or in combination with petrol in some newly developed advanced flex-fuel hybrid vehicles [11]. Because biomethanol has a higher specific energy yield than bioethanol, it is superior. Due to its high volumetric energy density and ease of storage and transportation, methanol is a good biofuel. It is also liquid at room temperature. Additionally, it is a simple, basic material that can be used to create a wide range of beneficial organic compounds with significant commercial applications. It can take the place of related compounds, including hydrocarbons generated from petroleum [29]. Both biological and thermochemical techniques can be used to create methanol. Conversely, not enough is known about the biological conversion processes, which are still being studied in laboratories. Understanding the microorganisms, their metabolic pathways, and the enzymes involved in the bioconversion process is crucial for the biochemical synthesis of methanol. It also involves knowledge of many parameters that are necessary for scaling up laboratory results to full-scale production facilities [30].

Biobutanol is being explored as a second-generation biofuel, alongside other alcoholic fuels. Biobutanol, a biofuel, is a recent addition to the fuel market. Multiple studies have demonstrated the advantageous effects of incorporating biobutanol into diesel and other fuel mixtures. Biobutanol outperforms bioethanol and biomethanol due to its reduced demixing issues in biobutanol–petroleum blends, lower corrosiveness, decreased vapor pressure, higher energy content, and higher flash point. The primary negative of biobutanol, despite its notable advantages over other bioalcohols, is its low productivity [31][32]. Long-chain alcohols, such as biobutanol and biopentanol, have superior qualities in comparison to lesser alcohols, such as ethanol and methanol. They can serve as blending constituents with diesel in a compression-ignition engine (CIE). Butanol and pentanol can be generated through the processes of biomass fermentation, conversion of bio-syngas, or biosynthesis from glucose using genetically modified microorganisms and cyanobacteria. The current scientific research aims to identify methods for reducing production costs. The conversion of bio-syngas via chemical catalysis enables the production of a blend of methanol, ethanol, and butanol [33].

Straight vegetable oil (SVO) is an alternative term for vegetable oil used as a fuel. Vegetable oil is a lipid composed of free fatty acids linked together by a glycerin backbone. Using biofuels or straight vegetable oils (SVOs) directly in compression-ignition (CI) engines, which are commonly used in transportation, is not recommended due to their challenging properties. The SVOs have high density, high viscosity, large molar masses, and low volatility due to the presence of unsaturated fats, which contribute to undesirable shower characteristics. These problematic characteristics lead to a more fragmented atomization process and exacerbate concerns about the blending of air and fuel. Carbon deposition in Jatropha is indeed higher than in diesel fuel, which can result in an increase in smoke emissions [34]. Out of these several alternative fuels, the most encouraging one is undoubtedly hydrotreated vegetable oil (HVO), which offers numerous benefits. HVO is synthesized via the hydrotreating of vegetable oils or animal fats, utilizing the same raw materials as biodiesel. Typically, additional processes, such as isomerization, are employed to enhance the cold flow characteristics. HVO can be co-produced with bio jet oil and green naphtha, depending on the catalyst type and operational conditions. This adds flexibility to the production process for HVO. HVO 100 is an environmentally friendly alternative to conventional fuel, derived from renewable and sustainable resources [35]. Diesel vehicle owners can transition to using HVO 100 fuel without necessitating any alterations to their engines. High-volatility oxygenate (HVO) significantly decreased the time it took for fuel to ignite because of its elevated cetane number. This characteristic also resulted in a decreased amount of energy released during the combustion process when the fuel and air were combined. The aforementioned study also indicated that this eco-friendly fuel exhibited reduced levels of soot and NOx emissions in comparison to petrodiesel. This can be attributed to the absence of aromatic components and the decreased mixing rate, respectively. Hydrotreated vegetable oil (HVO), sometimes known as “green diesel” in the industry, is a type of diesel fuel that is generated from biomass and has a paraffinic composition. HVO belongs to the category of “renewable diesels”, which include Fischer–Tropsch diesel (FT diesel) as well [36].

Biodiesel has gained popularity in the worldwide fuel market due to increased awareness of energy security. Biodiesel is an alternative to petroleum diesel that consists of a blend of alkyl esters derived from free fatty acids. It has gained considerable interest due to its low toxicity and great ability to be broken down by natural processes. Biomass oils are primarily used for their generation. Biodiesel is named as such because it is derived from biological sources and exhibits comparable performance to petrodiesel. Biodiesel is considered a clean energy source due to its ability to reduce the emissions of direct and indirect greenhouse gases such as CO_2, CO, SO_2, and HC; therefore, offering environmental protection [37]. Therefore, the use of biodiesel can contribute to the preservation of ecological equilibrium, as opposed to the use of fossil fuels. Biodiesel may be seamlessly blended and utilized in compression-ignition engines (CIEs) without requiring any alterations. To address potential stability and breakdown problems, biodiesel is commonly mixed with regular diesel at a ratio of 7–10% by volume (referred to as the B7–B10 blends). In order to enhance the mix percentages, engines must undergo modifications to improve their operational characteristics, such as injection timing, compression ratio, and injection pressure. Europe already has instances of captive fleets utilizing blending grades of B20, B30, and B100 [38].

Renewable diesel is composed of hydrocarbons that do not contain any aromatic components. Renewable diesel presents a superior alternative for addressing the problem of rapidly depleting fossil fuels and the limitations of biodiesel. The feedstock utilized for the production of renewable diesel, much like biodiesel, encompasses vegetable oils, animal fats, spent cooking oil, and lignocellulosic biomass. Renewable diesel is manufactured with the same objective as biodiesel production, which is to minimize the effects of CO_2 emissions and offer a more environmentally friendly combustion alternative compared to petroleum diesel. Renewable diesel, unlike FAME biodiesel, can be stored for an extended period of time since it shares similar qualities with petroleum diesel. It consists of a combination of straight-chain and branched saturated hydrocarbons (C15 to C18) and does not include any oxygen [39]. In addition, renewable diesel has exceptional cold-weather performance due to its high cetane number, making it easier to ignite compared to biodiesel. Renewable diesel has several benefits over traditional petroleum diesel, including a high heating value, comparable energy densities, excellent storage stability, and non-corrosiveness. These positive features make renewable diesel a superior solution for enhancing our energy sources. Renewable diesel is a broad term that describes the latest generation of diesel fuels made from biomass. There are two categories of technology that can be used to produce renewable diesel: hydroprocessing (HVO) and thermochemical processes such as pyrolysis and gasification. These fuels can be used in conventional automobiles without the need for blending, as stated in reference [40]. HVO is devoid of oxygen, aromatics, and sulfur, making it superior to both FAME and diesel in terms of qualities such as a higher cetane umber, a higher heating value, and improved oxidative stability features. HVO lacks the lubricating properties that make FAME particularly advantageous. The utilization of customized green diesel blends, which consist of a combination of petrodiesel and oxygenated biochemicals, has great potential for addressing the environmental problem. Green diesel is an alternative term used to refer to renewable diesel fuel. Green diesel, with equal chemical properties to petrodiesel, can be used either in its pure form or as a blend with petrodiesel [41].

Bio-gasoline is a form of gasoline derived from biomass, such as algae. Similar to conventionally manufactured gasoline, it consists of hydrocarbons containing 6 (hexane) to 12 (dodecane) carbon atoms per molecule and is suitable for use in internal-combustion engines. Contrary to conventional gasoline derived from oil, bio-gasolines are mostly derived from plants, such as beets and sugarcane, or cellulosic biomass, which is typically seen as plant waste. Several governments and prominent multinational organizations have backed the growth of several types of algae as a source of liquid fuel. However, green algal petrol has not been included so far [42]. Although algae biodiesel is a very sustainable substitute for traditional petrol and has received significant investment, bio-gasoline is distinct from other biofuels, such as biobutanol and bioethanol, as it is not an alcohol. However, it shares chemical similarities with biodiesel, which is also derived from carbon-based sources. Bio-gasoline, due to its lighter components, exhibits reduced pollutant emissions during combustion, owing to its distinct physical features. Moreover, the energy obtained from bio-gasoline is significantly greater than that from corn-based ethanol when mixed with regular gasoline due to the larger molecular weight of the components derived from algae [42]. In the present research areas, numerous thermochemical pathways exist to transform biomass into synthetic fuels suitable for transportation purposes. The precise nomenclature for this collection of biofuels has not been established, and “synthetic liquid biofuels” is the most suitable categorization currently available. The process of biomass gasification, which generates syngas, and the subsequent thermochemical pathway are commonly known as “biomass to liquids”. Synthetic biofuels provide comparable or even superior characteristics to their fossil fuel counterparts [43].

Gaseous biofuels, such as biogas, biomethane, biohydrogen, and syngas, can be employed to produce both thermal and electrical energy. The energy generation system described is commonly referred to as a sustainable energy system due to its ability to reduce harmful emissions and contribute to economic development. Subsequently, biohydrogen is acknowledged as the most feasible alternative to the conventional energy sources. It is mostly derived from renewable and non-renewable hydrocarbon resources, serving as a secondary energy source. Biohydrogen is anticipated to have a vital function in future global energy sectors as an energy provider [44]. Biogas is a form of gaseous biofuel that is used in the energy industry. Microbes facilitate the production of biogas through the anaerobic degradation of organic matter. Biogas can be utilized through several processes to generate a range of transportation fuels, including CBG, LBG, hydrogen, methanol, dimethyl ether, and Fischer–Tropsch (FT) fuels, which are the most probable alternatives [45]. Biomethane derived from biomass is an environmentally friendly substitute for supplying compressed natural gas vehicles. Biomethane can be produced by the process of anaerobic digestion or the bio-syngas methanation process. The initial procedure, which is a well-developed technique, generates biogas from organic substances. Subsequently, biogas can undergo a purification process to produce biomethane, also known as upgraded biogas. Biosynthetic natural gas (bio-SNG) refers to the biomethane that is produced from bio-syngas. Currently, the profitability of biomass gasification technology for SNG production remains unattainable [46]. Bio-DME, or dimethyl ether, is an ether that may serve as both a fuel additive and a standalone fuel in internal-combustion engines (CIEs). Bio-DME is generated through the process of biomethanol dehydration or from bio-syngas in conjunction with biomethanol. Under normal settings, dimethyl ether (DME) exists in a gaseous state, which limits its use to specialized vehicles equipped with a pressurized fuel chamber, similar to those used for liquefied petroleum gas (LPG) [47]. Bio-ETBE and bio-MTBE are types of bio-ethers, which are fuels commonly employed as additives to enhance the performance of fuel in the combustion chamber. The synthesis of bio-ETBE/bio-MTBE involves the chemical reaction between isobutylene and bioethanol/biomethanol [48]. Biohydrogen can be generated from biomass and subsequently utilized for energy generation via fuel cells (FCs). To generate biohydrogen, bio-syngas that is high in H2 can be created by gasifying biomass in the presence of water. The water–gas shift reaction is utilized to enhance the H2 concentration, as indicated by the references. Additional methods for generating biohydrogen include biomethane reforming, bioethanol reforming dark fermentation, and photo-fermentation [49]. Biopropane, often known as bio-LPG, has the potential to serve as a substitute for fossil LPG. It can be generated using a single-step catalytic synthesis of the syngas produced from biomass gasification and also as a by-product of HVO. Bio-LPG is already produced in small quantities as a by-product of various biofuel synthesis techniques [50].

Biogas is being converted into compressed biomethane (CBG) in several countries. CBG is a renewable alternative to compressed natural gas (CNG) and is mostly used in vehicles, particularly cars and buses. In recent years, there has been a growing fascination with liquefied biomethane (LBG) as a substitute for liquefied natural gas (LNG) in the field of heavy transportation. Additionally, there are alternative choices accessible [51]. In addition to CBG and LBG, biogas can be utilized for the generation of syngas, which can then be employed for the production of sustainable variants of fuels such as hydrogen, methanol, or DME. These fuels possess distinct attributes and capacities compared to CBG and LBG, rendering them potentially viable for other components of the renewable energy infrastructure that require development [52]. Liquid biogas (LBG) has developed as a viable alternative fuel for both heavy road and sea transportation. Multiple truck manufacturers have commenced the production of engines capable of operating on methane fuel. When considering CBG, LBG, or methanol as maritime fuels, it is evident that all of these alternative fuels provide distinct advantages over traditional fuel oil in terms of their environmental impact. To use biogas as a fuel for vehicles, it is necessary to purify it by removing CO_2 and other contaminants [47]. This process enhances the methane concentration and thus increases the heating capacity of the biogas. Bio-CNG is a fuel derived from biodegradable waste that is both environmentally friendly and sustainable. Bio-LNG, derived from organic sources such as household trash, sludge, manure, or agricultural waste, is an optimal environmentally friendly fuel for heavy transportation. By converting garbage into fuel, it contributes to the concept of a circular economy [53].

4. Key Components and Technological Features of Biofuel Vehicles

In the context of biofuels, liquid biofuels are often utilized by either blending them with conventional petrol or diesel or by completely substituting them for traditional fuels. Typically, the utilization of liquid biofuels does not require further particular modifications. The major components and technological aspects of liquid biofuel vehicles closely resemble those of traditional petroleum-based fuel vehicles [54]. In this section, the researchers shall examine gaseous biofuel cars. Biogas cars are ideal for high-mileage, centrally fueled fleets, as they offer comparable fuel range support for applications that operate inside a location that has dependable compressed biogas refueling infrastructure. Biogas offers several benefits as a transportation fuel, such as its abundant supply within the country, extensive distribution infrastructure, and lower greenhouse gas emissions compared to traditional petrol and diesel fuels. Experienced retrofitting specialists can efficiently and securely convert a wide range of vehicles to run on biogas using aftermarket conversion equipment. CBG and LBG are regarded as alternative fuels that provide promising prospects in this domain [51][53].

There are three types of versatile cars that run on gaseous biofuel. Specialized cars are exclusively engineered to operate solely on gaseous biofuel. Bi-fuel vehicles are equipped with two distinct fueling systems, allowing them to operate on either gaseous biofuel or petrol. Dual-fuel automobiles are equipped with fuel systems that operate on natural gas but rely on diesel fuel for ignition assistance. This layout is often restricted to vehicles designed for heavy-duty applications. Gaseous biofuel cars store biogas in pressurized tanks, maintaining it in a gaseous condition [55]. LBG enables more fuel storage capacity in vehicles due to its liquid state, resulting in a higher energy density compared to CBG. LBG is highly suitable for Class 7 and 8 trucks that require an extended range. Frequently, the selection of fuel is influenced by factors such as the specific requirements of the vehicle’s application (e.g., power needs) and the desired driving distance. The range of gaseous biofuel vehicles is often shorter than that of similar diesel or petrol vehicles because natural gas has a lower energy density. Supplementing storage tanks might extend the distance that can be covered, but the extra weight might reduce the amount of goods that can be carried. When utilized as a fuel for vehicles, gaseous biofuel can provide advantages in terms of the greenhouse gas (GHG) emissions over its entire life cycle compared to traditional fuels [56]. However, the extent of these benefits depends on factors such as the type of vehicle, its usage pattern, and the calibration of its engine. Furthermore, natural gas mitigates certain engine pollutants. Tailpipe emissions are the by-product of gasoline combustion in an automobile’s engine. The emissions of major concern encompass the regulated hydrocarbon emissions, nitrogen oxides (NOx), carbon monoxide (CO), and carbon dioxide (CO_2) [57].

5. Commercial Biofuel Vehicles

There are various gas vehicles available commercially on the market manufactured through various companies. **Table 1** lists some of the vehicles and their specifications that are available on the market.

Table 1. Biofuel vehicles by various companies and their specifications.

Company Name	Vehicle Model	Specifications
Cadillac	Cadillac Escalade 2WD (2024) 	Fuel: Biodiesel (B20) Type of Vehicle: SUV Conventional Fuel Economy: 23 mpg Engine/Motor(s): 3.0L V6 Transmission: Auto Drivetrain: RWD
GMC	GMC Yukon/Yukon XL 2WD (2024) 	Fuel: Biodiesel (B20) Type of Vehicle: SUV Conventional Fuel Economy: 23 mpg Engine/Motor(s): 3.0L V6 Transmission: Auto Drivetrain: RWD
Chevrolet	Chevrolet Silverado 2WD (2024) 	Fuel: Biodiesel (B20) Type of Vehicle: pickup Conventional Fuel Economy: 26 mpg Engine/Motor(s): 3.0L V6 Transmission: Auto Drivetrain: RWD
Ford	Ford Explorer AWD FFV (2022) 	Fuel: Ethanol (E85) Type of Vehicle: SUV Alternative Fuel Economy: 13 mpg Conventional Fuel Economy: 19 mpg Engine/Motor(s): 3.3L V6 Transmission: Auto Drivetrain: AWD

Company Name	Vehicle Model	Specifications
Dodge	Dodge Challenger SRT Demon 170 (2023) 	Fuel: Ethanol (E85) Type of Vehicle: sedan/wagon Alternative Fuel Economy: 15 mpg Conventional Fuel Economy: 9 mpg Engine/Motor(s): 6.2L V8 Transmission: Auto Drivetrain: RWD
GMC	GMC Sierra 2WD (2023) 	Fuel: Ethanol (E85) Type of Vehicle: pickup Alternative Fuel Economy: 13 mpg Conventional Fuel Economy: 18 mpg Engine/Motor(s): 5.3L V8 Transmission: Auto Drivetrain: RWD

6. Pros and Cons of Biofuel Vehicles

The biofuel vehicles have advantages and disadvantages when used in the transportation system. **Table 2** discusses the pros and cons of biofuel vehicles.

Table 2. Pros and cons of biofuel vehicles [58].

Pros	Cons
Biofuels are renewable and promote sustainability.	Biofuels require pre-treatment processes before use.
Offer higher reliability.	Developing biofuel technologies can be expensive.
Can be produced locally.	Need to improve the efficiency of biofuel production technologies.
Reduce dependence on foreign energy sources.	Procurement of subsidies for biofuel production is needed.
Can help stabilize energy prices.	Funding for research and development is needed.
Biofuels support rural development.	Scaling up biofuel production to commercial levels can be challenging.
Biofuels help reduce air pollution.	Establishing an efficient collection network for biofuel feedstock can be complex.

Pros	Cons
Biofuel production can make use of marginal lands and agricultural waste.	Biofuels require specialized storage facilities.
Biofuels enable carbon sequestration.	Biofuel production can compete with food production.

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