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State-of-the-art in bioresources for sustainable transportation

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Abstract

Achieving circularity in the transportation sector is the strongest need of the hour and one of the pathways to achieve this is by embracing sustainable bio-energy resources. Considering this need, we investigated and reviewed the state-of-the-art readiness of the current bioresources i.e., biofuels. We provide a fresh overview of various biofuels (bioethanol, biohydrogen, biodiesel) production pathways followed by the landscape of current global production and consumption. In these discussions, we alluded to the prospects of algae-derived biofuels together with the techno-commercial aspects of biofuels toward achieving competitiveness in costs, technology and system design. The review also discussed the limitations of existing batteries over biofuel cell technology in terms of vehicle weight, storage capacity, cost and greenhouse pollution. Next, we discussed the advancement in biofuel cells (BFCs) and the challenges to the successful implantation of biofuel cells in the automotive sector. The development of a new e-biofuel cell system infrastructure was also elaborated to reduce the existing BFCs current problems and their environmental-economical sustainability was discussed. The review concluded by summarizing the current market scenario, global forecast for green energy resources and future directions in the area.

Keywords: Biofuels; electric vehicles; environmental impact; social roadmap

Abbreviations:

ABC	Advanced battery consortium
BFs	Biofuels
BEVs	Battery powered electric vehicles
BFCs	Biofuel Cells
BFCV	Biofuel cell vehicles
BFCEVs	Biofuel cell electric vehicles
CHP	Combined heat and power generation systems
CNG	Compressed natural gas
DMFC	Direct ethanol fuel cell

DVs	Diesel vehicles
Evs	Electric vehicles
FCVs	Fuel cell vehicles
FCEBs	Fuel cell electric buses
FFVs	Flexible fuel vehicles
FCHEVs	Fuel cell hydrogen electric vehicles
GHC	Greenhouse gas emissions
GVs	Gasoline vehicles
ICE's	Internal Combustion Engine
LoNo	Low or no emissions distribution
MAC	Marketing companies
MPP	Minimum purchase price
PEMFC	Proton exchange membrane fuel cell
RFS	Renewable fuel standard
SDGs	Sustainable development goals
SDS	Sustainable development scenario
SER	Steam-ethanol reforming
SOFC	Solid-Oxide Fuel Cell
WGS	Water-gas shift

Nomenclatures:

CO_2	Carbon-di-oxide
H_2	Hydrogen gas

1. Introduction

The energy systems in the post-covid era must not only be affordable but should also not adversely affect the environment [1, 2]. These systems must mitigate the effects of climate change [3], reduce toxic pollutants and must be replacement of natural oil reserves [4-6]. In view of this need, there is a sharp and rising focus on generating more efficient energy supply chains to obtain carbon neutrality [7, 8]. One of the most promising ways to achieve this is by generating and using clean electricity from non-fossil fuels i.e., biofuels. Biofuels (BFs) are rapidly advancing in automobile sector as alternative sources of renewable energy due to their non-polluting characteristics and low-cost competitiveness as compared to fossil fuels [9, 10]. In current scenario, technologies are moving forward to use the cheapest way to accelerate the production of BFs [11, 12].

Presently, the transport sector uses ~50% of global oil which contributes to ~ 25% of global CO_2 emissions [13]. Therefore, improving energy security and reducing the greenhouse gas emissions (GHG) generated by vehicles has become an important factor for governments to push the use of alternatives to petroleum-based fuels. In recent decades [14-17], numerous fuels have been used in the transport sector such as liquefied petroleum gas (LPG), compressed natural gas (CNG) [18-20] and electricity [21]. A new need for the use of biofuels stems from three major factors: (i) Energy security, (ii) Environment, and (iii) Fuel quality as shown in Fig. 1 [22-27].

Energy Security: Fuels based on renewable energy sources (RES) such as biofuels and electricity and hydrogen generation from RES are all possible avenues to deal with the current transport environmental problems, with different vehicles such as EVs and FECV having the potential to use lower- or zero-carbon energy sources.

Environment Security: Transport, while being the fastest growing sector in terms of energy use, also emits one-quarter of the EU's total greenhouse gas emissions. Carbon capture and sequestration (CCS) technologies, a process to capture CO_2 from industrial exhaust streams and inject it into underground storage sites, when combined with bioelectricity, have the potential for a carbon-negative environment.

Sustainable Production: The literature highlights the electric energy conversion trends for the future transport of biofuels. However, to fully contribute to sustainable transport production, a new bio-electric energy changeover is needed.

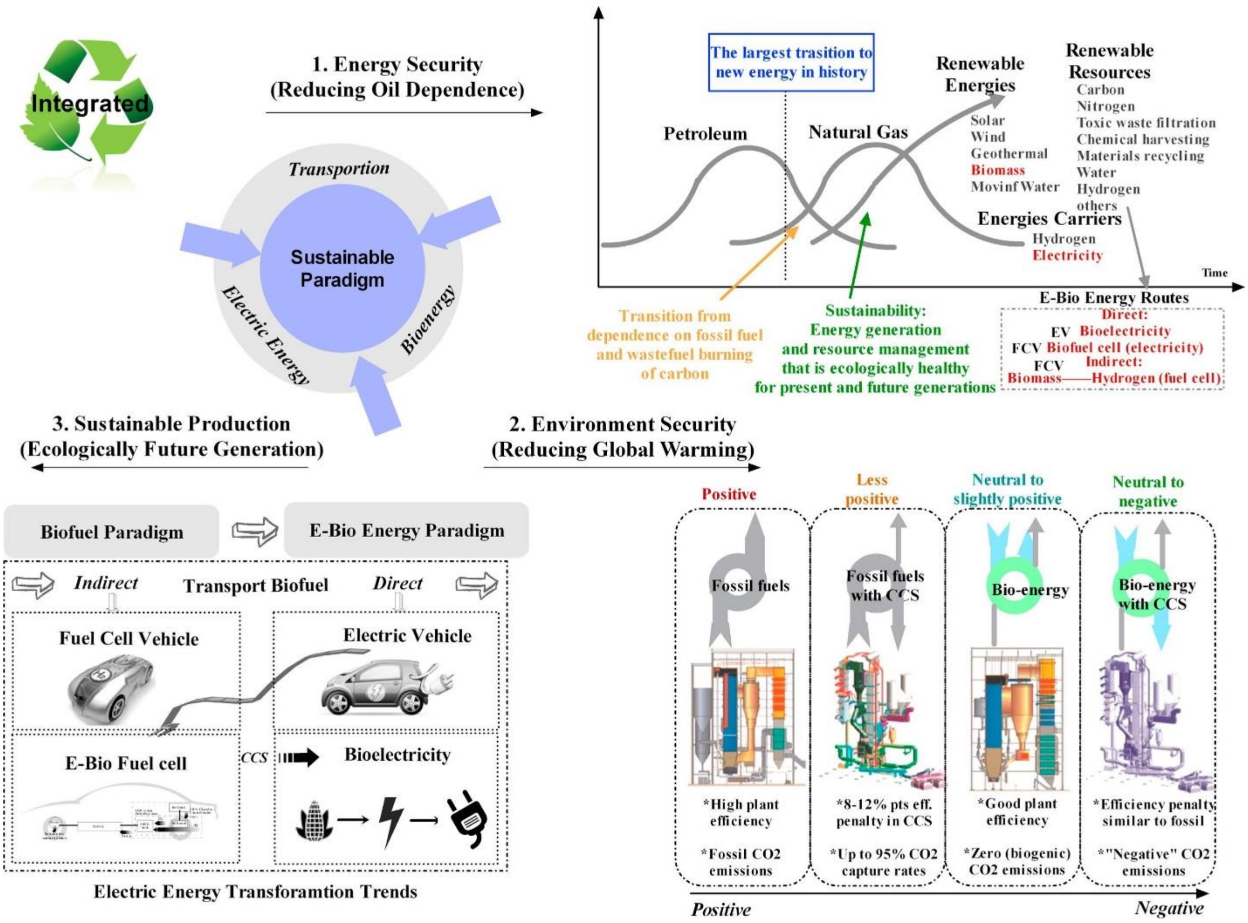


Fig 1. Integrated sustainable framework for sustainable transportation [28]

Although BFs now offers a solution to address the future global sustainable energy requirements but there are still a number of issues that needs to overcome [29]. The biocatalytic fuels that are currently being used are glucose, lactate and ethanol. Other well-known fuels i.e. alcohols, fatty acids, methane and carbohydrates are also being explored [30]. Table 1 is a summary of various different routes for the production sources of BFs.

Table 1. Various routes to biofuel production in electric vehicles

Vehicles	**Biofuels**	**Production process**	**Feedstock**		**References**
			Group	**Specification**	
Diesel Vehicles (DVs)	Biodiesel	Trans-esterification	Soybeans		[10]
Flexible Fuel Vehicles (FFVs)	Bioethanol	Fermentation	Starch-based biomass	Corn	[11]
			Lignocellulosic biomass	Switchgrass	[11]
Fuel Cell Vehicle (FCVs)	Biohydrogen	Reforming	Corn ethanol		[18]

Across numerous approaches for the production of BFs, enzymatic biofuel cells are gaining remarkable attention as sustainable energy storage devices, mainly due to the increasing lifespan and energy density. Through the use of an enzyme cascade system, the degree of fuel oxidation improves the electron transfer routes and enzymatic immobilization techniques [10]. Also, fuel cell devices are gradually replacing internal combustion engines in the transport sector [12].

This review critically examines the literature to explore and suggest clarity on the processes of biofuels such as the production of biohydrogen, biogas, biodiesel and bioethanol, as well as biofuel cells for electric vehicles, their penetration into the automotive market and prospects.

2. Biofuels production pathways

2.1 Bioethanol

Bioethanol is mainly produced from biomass materials. Generally, it is produced by the fermentation of glucose, in which oxygen is not enough for normal cellular respiration and aerobic respiration takes place in yeasts, thus converting glucose into ethanol and carbon dioxide [31].

$C_6H_{12}O_6 \longrightarrow 2CH_3CH_2OH + 2CO_2$…………………………………………………………........(1)

Glucose usually comes from starchy crops such as corn and wheat or sugar crops like sugar cane and beetroots. Presently, non-food sources i.e., herbaceous and woody biomass or waste used to produce cellulosic biomass are also used as raw material for ethanol production [32].

As shown in Fig. 2 [30] sucrose-based biomass and starch-based biomass are mainly used as raw materials for the generation of bioethanol [33]. For sucrose-based biomass, such as sugarcane or beetroot, the juice is first mechanically pressed from cooked biomass and fractionated. Thus, yeasts metabolize sucrose to ferment hexoses in ethanol. Finally, ethanol is separated and recovered by distillation. As far as starch-based biomass is concerned, starch grains such as corn, cereals, barley or wheat are pretreated by crushing and grinding [34-36]. Thus, food from starch cultures is enzymatically hydrolyzed to a hexose. Yeasts convert hexose puree to biochemical ethanol [37-39]. The hydrated ethanol is subsequently purified by distillation. Starch-based route and sucrose-based route both are identical but starch-based pathway consumes more energy than the sucrose-based pathway due to an additional step of converting starch to glucose [40-45]. In general, the use of starch/sucrose is a reliable technology to which few significant improvements have recently been made [30, 46-49].

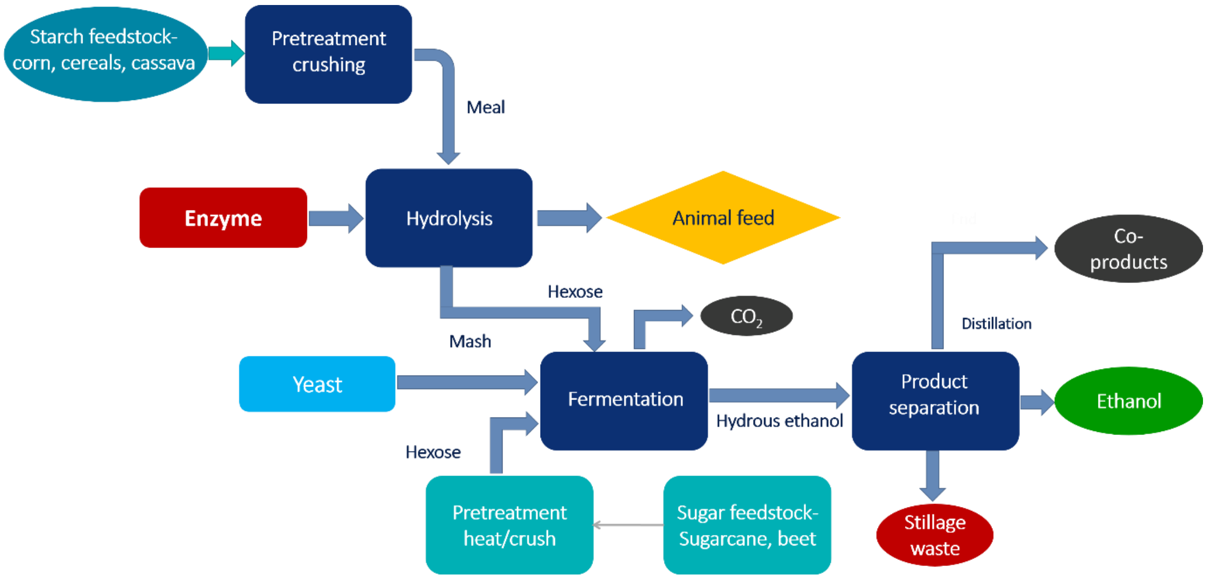


Fig.2 Conversion routes for sugar and starch feed-stocks in the production of bioethanol

2.2 Biohydrogen

It is mainly the bioethanol that is used for the production of biohydrogen [50]. Hydrogen rich gases are the main products that are obtained from biomass conversion and this is the most effective procedure to convert hydrogen energy into efficient electricity to use for automotive purposes. These liquids have high energy density and can be transported with minimal new delivery infrastructure and at a relatively low cost to distributed refuelling stations or stationary power sites [51-53].

Steam-ethanol reforming (SER) through reaction pathways and thermodynamics has been extensively studied recently [54, 55]. Mostly they preferred the processes converting bioethanol into biohydrogen that involves a reaction with H_2O in the SER process [56, 57] (Fig. 3).

The reaction between ethanol and steam at high temperatures in the presence of a catalyst can be described as :

$C_2H_5OH + H_2O \longrightarrow 2CO+4H_2$……………The heat of release=26kJ.mol^{-1}…………….(2)

This strong endothermic reaction requires 800°C temperature to heat the reactor which is necessary to achieve high conversion at residence times of one second. The carbon monoxide produced further reacts with high-temperature steam that produces hydrogen via the water-gas shift (WGS) reaction. Lastly, this hydrogen is separated and purified for further use [58].

2.3 Biodiesel

Biodiesel is a renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease. Biodiesel meets both the biomass-based diesel and overall advanced biofuel requirements of the Renewable Fuel Standard. Renewable diesel, also called "green diesel" is distinct from biodiesel [59].

It is composed of a mixture of monoalkyl esters of long chain fatty acids and technically it has been defined as a monoalkyl ester [47]. In general, biodiesel can be used in standard diesel engines, unlike vegetable oils that must be used in diesel engines converted into fuel. It can be used alone or mixed with petro-diesel (Fig. 4). Biodiesel performance in cold weather depends on the blend of biodiesel, the feedstock, and the petroleum diesel characteristics. In general, blends with smaller percentages of biodiesel perform better in cold temperatures [60]. For the best cold weather performance, users should work with their fuel provider to ensure that the blend is appropriate [61].

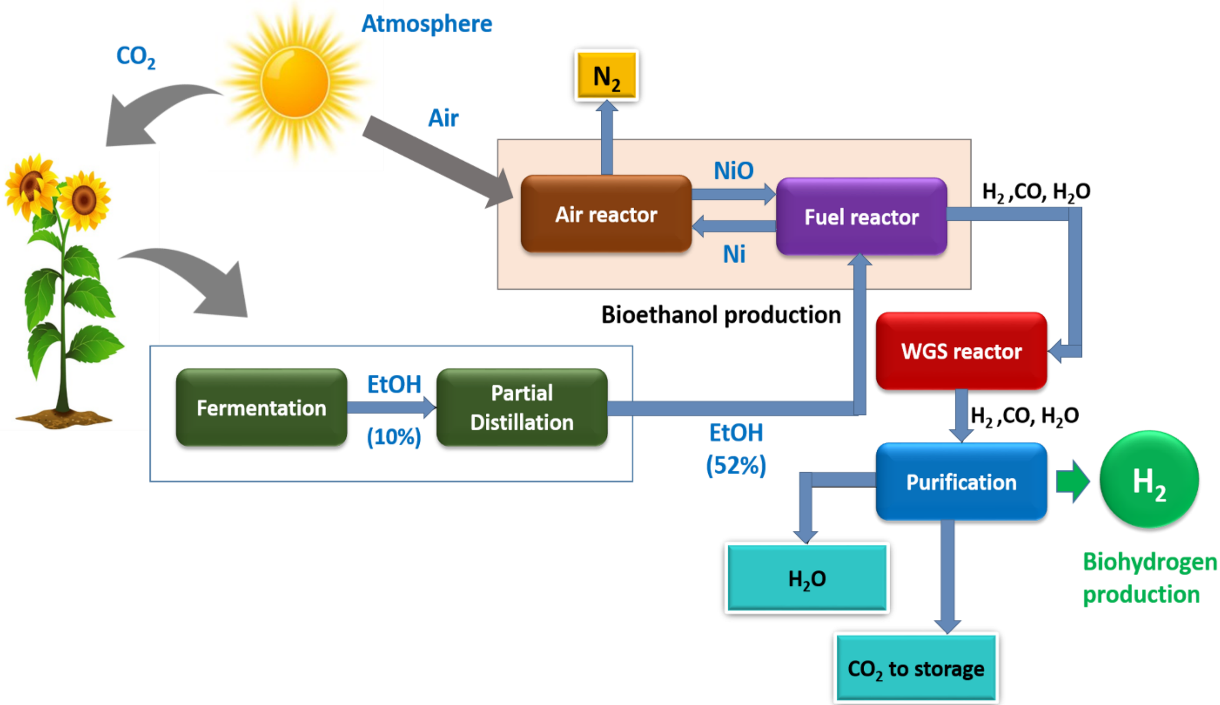


Fig. 3 Biohydrogen production process

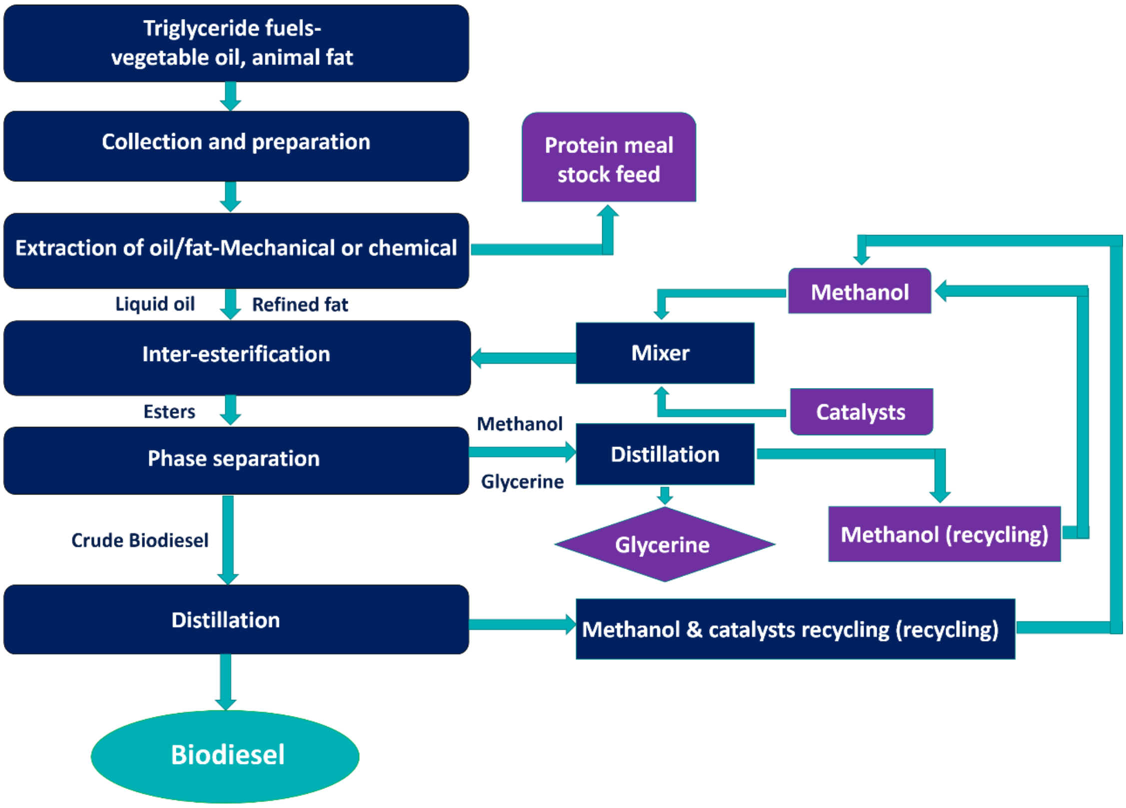
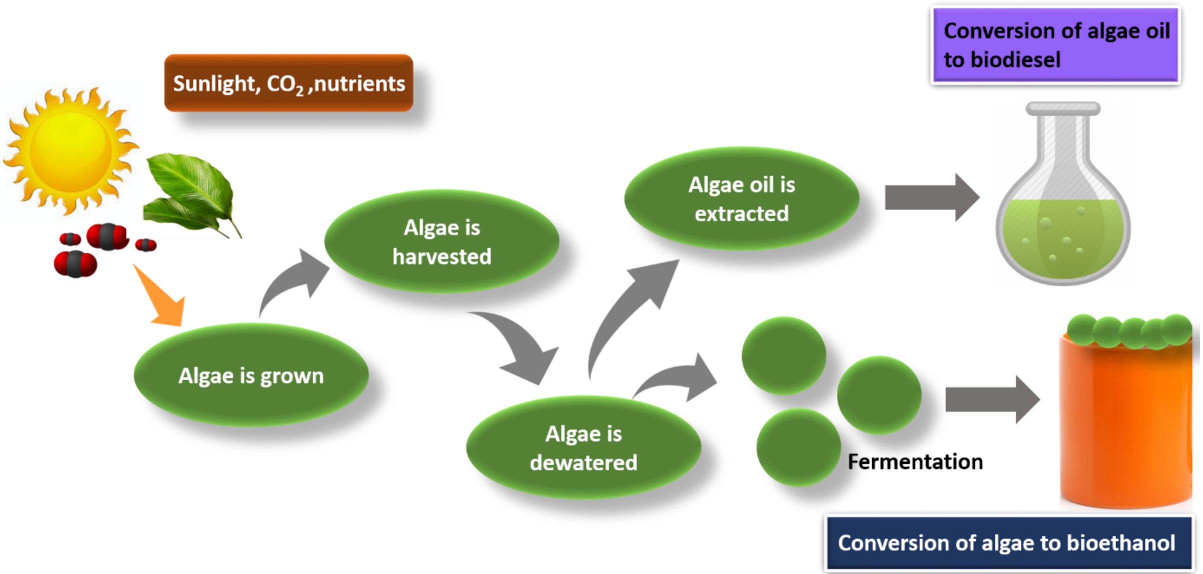


Fig. 4 Production pathway of biodiesel

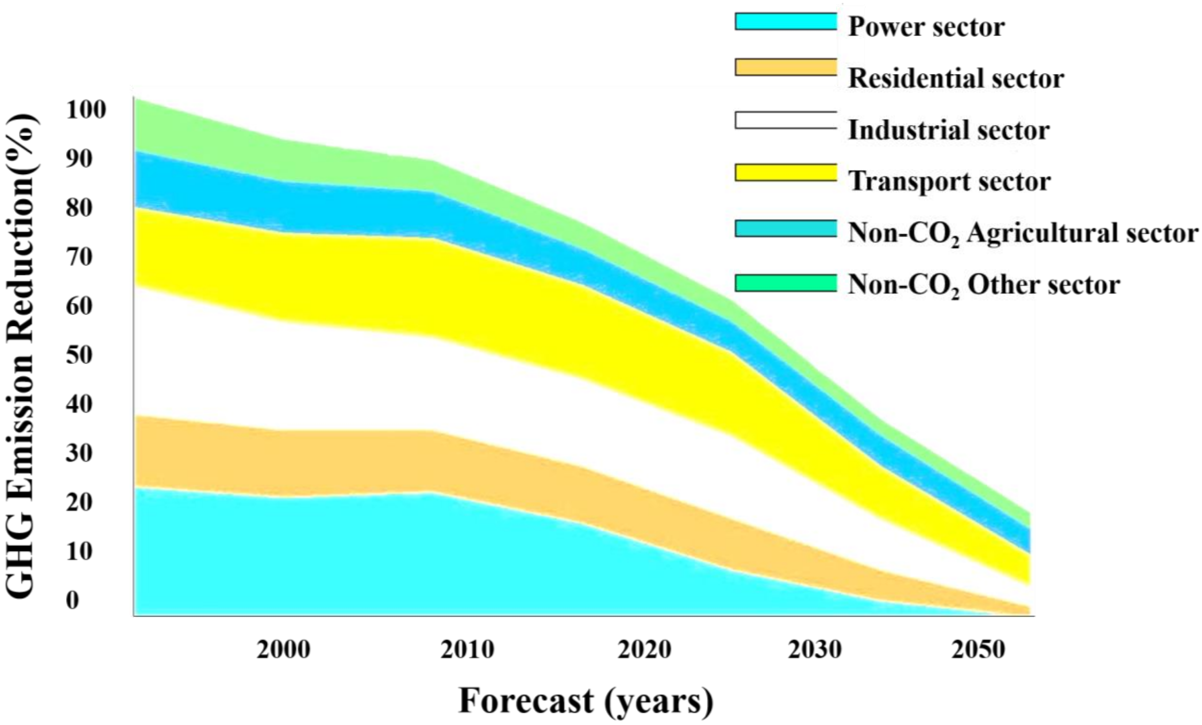
2.4 Algae bio fuel

Algae biofuels may provide a viable alternative to fossil fuels. Microalgae are a diverse group of single-cell organisms that have potential solutions for liquid transportation fuel requirements through several avenues [62]. Algae efficiently use CO_2, and are responsible for more than 40% of the global carbon fixation, with the majority of this percentage coming from marine microalgae. Algae can produce biomass very rapidly, with some species doubling in as few as 6h, and many exhibiting two doublings per day. The raw material of algae contains a very high fraction of oil so it can be used for the production of advanced biofuels through different conversion processes as shown in Fig 5a. Globally, algae biofuel has proven itself economically sustainable raw material and it is a good replacement for fossil fuels for transportation applications [63]. The applications of algae are evident through the daily consumption of food products, non-food products, fuel and energy. The overall potential for algae applications generally shows that this raw material remains an untapped resource and could be of enormous commercial benefits for the global economy in general because algae exist seamlessly compared to land plants. There are no environmental footprints of algae-derived biofuels and food security issues are also resolved [62, 64]. Fig. 5b shows the current state of algae as a potential raw material with various benefits for solving global energy demand and controlling environmental pollution. The marketing of algae biofuels still presents many challenges to obtaining competitiveness in terms of costs of raw materials, technology and system design. In recent decades, governments and businesses have promoted advances in research and marketing of biofuel for algae of sponsored numerous pilot programs for algae fuel reduction. According to the research [65], the production of ethanol and diesel from algae is possible in terms of technological processes.

Algae are a favorable source of renewable bioenergy, with the advantages of photosynthetic efficiency, biomass productivity [66] and oil content. Furthermore, it also avoids competition for arable crops with terrestrial crops, with the merit of eliminating pollution and carbon sequestration. Cyanobacteria are attractive for the marketing of biofuels because they can easily transform and accumulate biomass quickly [67-69]. Researchers have redirected the metabolism of different strains to produce specific products, such as ethanol and alkanes of the diesel range. Genetic modification could redirect the metabolic pathway of cyanobacteria to produce desirable end products. Algenol Biotech LLC company with the National Renewable Energy Laboratory, the Georgia Institute of Technology and Reliance Industries Limited aims to improve the productivity of cyanobacteria. Joule Unlimited has designed a cyanobacterium that secretes hydrocarbon-based fuel directly and has successfully tested its platform. However, there is a long road from the pilot scale to commercialization [70-72].



(a)



(b)

Fig. 5 (a) Algae biofuel production process **(b)** GHG emission reduction projection [62]

2.5 Social concerns

Sugarcane is used as a feedstock in Brazil & corn in the USA is the feedstock used for the production of first-generation bioethanol. However, bioethanol poses problems, which means it is produced by food [40-42] so this can harm food security. In 2007-2008researchers suggested that the bioethanol produced from the agricultural raw product by harvesting, and the use of commodities by financial investors probably had a significantly greater impact on food prices than biofuel production [43, 44] and therefore, food security remains a critical issue for the development of biofuel policies.

Further research has continued to make reasonable non-food resources such as household waste, corn- stoves, straw and wood as raw materials to produce bioethanol. These resources significantly reduce the GHGs and the raw materials for ethanol production [45]. Globally companies are highly involved in R&D on the development of second-generation bioethanol; but only a few companies have reached the point of demonstrating the process in a pilot plant because their main concern is about the extent of fossil fuels that would be used in the production of bioethanol [42, 46].

5. Penetration of biofuels in the analysis of the motor fuel market

This section analyses whether biofuels are serving the automotive fuel market.

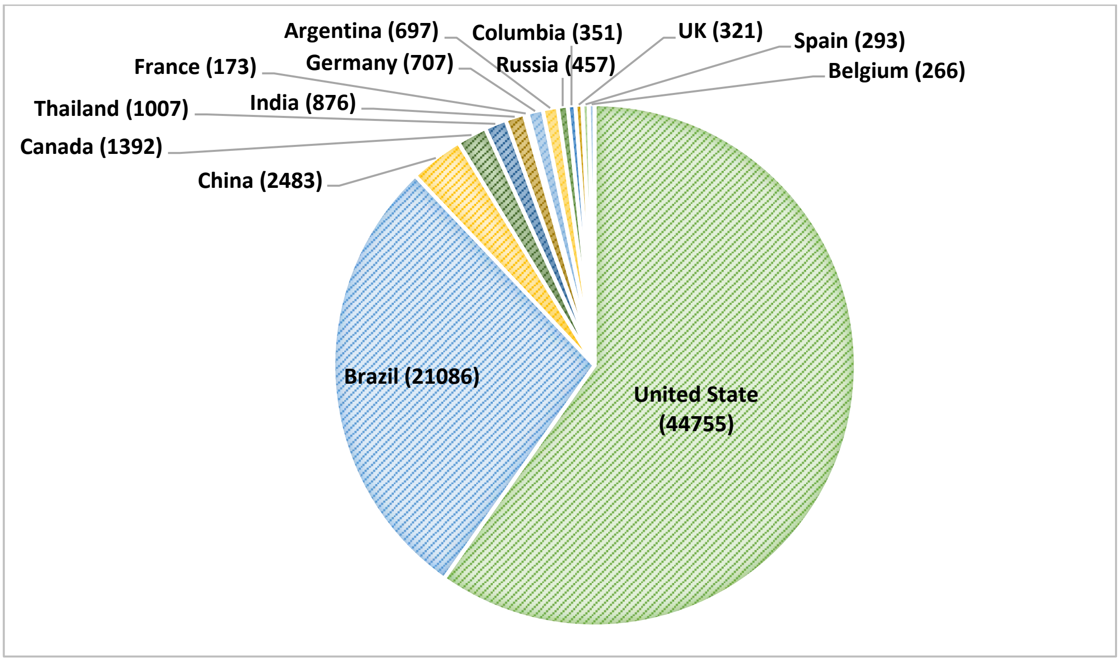
3.*1 Analysis of biofuel production*

The two main biofuel producers, the United States and Brazil, contributes to almost 82% of all biofuel production. The production of biofuels for transport grew by 7% on an annual basis in 2019 and over the next five years an annual production growth of 3% is expected. Fig. 6 shows the analysis of biofuel production considering first, second, third, fourth generation efficiency and consumption in several leading countries [47]. Global biofuel production will continue to be supplied predominantly by traditional feedstock; sugarcane and maize for ethanol and various vegetable oils for biodiesel production. Biodiesel produced from used cooking oil will continue to play an important role in the European Union, Canada, USA and Singapore. In most countries, biofuel policies aim to reduce GHG emissions and dependency on fossil fuels. Therefore, markets are mainly supplied domestically, leaving the international trade share relatively low and projected to decrease even further over the coming decade. World biodiesel trade is projected to decrease by 25% from current levels, largely reflecting declining demand for palm oil-based biodiesel in the European Union; ethanol trade will decrease moderately. On the export side, shipments from Indonesia are expected to decrease, reflecting high domestic demand [73].

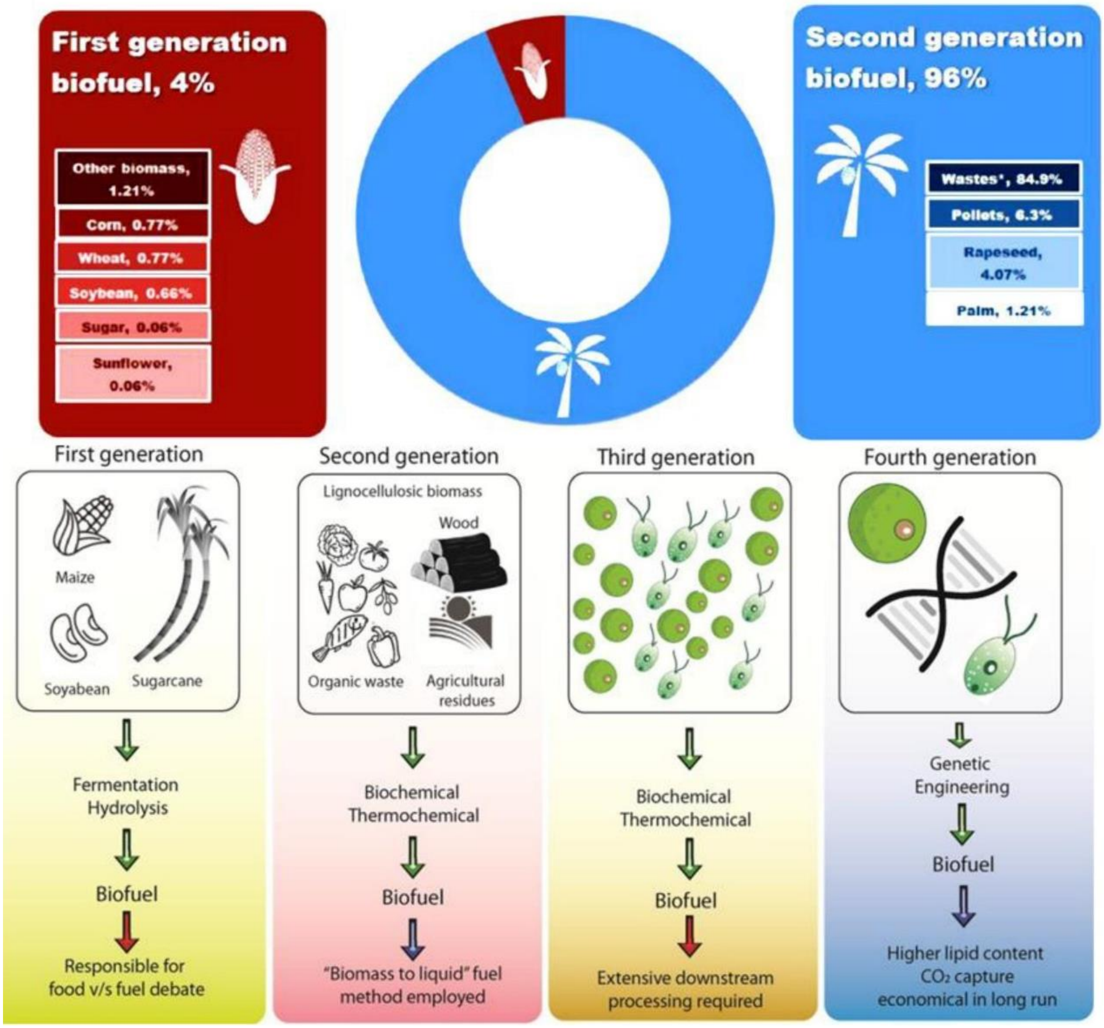
3.2 Analysis of biofuel consumption

A sustainable development scenario (SDS) requires a greater consumption of biofuels in road, air and maritime transport. Aviation biofuel production of around 15 million liters in 2018 represented less than 0.01% of the demand of aviation fuel in the USA, it means that a very significant market development is needed to provide the production of aviation biofuels required to be on roads in 2030 [48, 74]. In the maritime sector, the use of biofuels is under consideration in some cases, although the costs are currently higher for biofuels which means absorption stays low [49]. According to the International Energy Agency, the growth rate of biofuel consumption in transport must increase considerably in order to remain in line with the United Nations sustainable development goals [51]. In Brazil, total fuel consumption is expected to further increase over the projection period and ethanol and biodiesel consumption are projected to grow proportionately. China is not expected to implement a nationwide E10 mandate, as proposed in 2017, because this programme depends on maize stock levels which have been decreasing since 2017. Therefore, this outlooks assumes that China will maintain the lower blending rate of 2% to 2030. Blending mandates are expected to evolve over the projection period for some emerging economies. In Indonesia, both total diesel use and biodiesel consumption are expected to increase over the outlook period. By 2030, India's ethanol blending rate is projected to be about 8%, with sugarcane-based ethanol contributing significantly to meet this target. However, the projection is expected to remain below the E20 goal the government seeks to achieve by 2030 owing to the limited supply of feedstuffs, mainly molasses, which would remain as the main feedstuff [75].

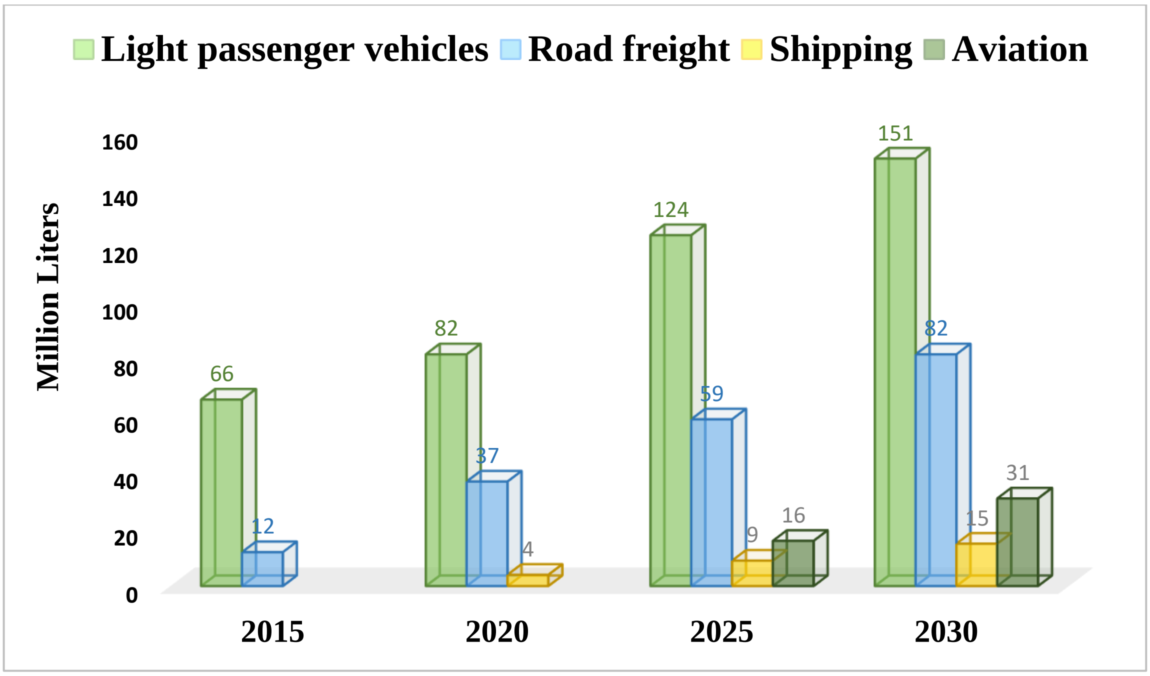
The lockdown measures and economic decline resulting from the COVID-19 pandemic decreased global fuel demand in 2020. COVID-19 curtailed the global transportation oil use; however, industrial use of fossil fuels was less affected. The United States and Brazil recorded the highest reductions in ethanol consumption and drove down global demand. Indonesia and Thailand increased biodiesel use owing to higher blend rates, while decreasing diesel use. Production margins for biofuels were affected by the higher maize and vegetal oil prices, which, combined with declining fossil fuel prices, created an unstable scenario; government support relieved some of the pressure on markets. Increasing use of ethanol in industry, driven by its use as a sanitizer in response to the COVID-19 pandemic, also helped sustain biofuels production. Biodiesel also played a more significant role in the production of electricity. The use of biofuels in sectors other than transportation was less affected [75].



(a)


First generation biofuel, 4%
Other biomass, 1.21%
Corn, 0.77%
Wheat, 0.77%
Soybean, 0.66%
Sugar, 0.06%
Sunflower, 0.06%
Second generation biofuel, 96%
Wastes*, 84.9%
Pellets, 6.3%
Rapeseed, 4.07%
Palm, 1.21%
First generation
Maize
Soyabean
Sugarcane
Fermentation
Hydrolysis
Biofuel
Responsible for food v/s fuel debate
Second generation
Lignocellulosic biomass
Wood
Organic waste
Agricultural residues
Biochemical
Thermochemical
Biofuel
"Biomass to liquid" fuel method employed
Third generation
Biochemical
Thermochemical
Biofuel
Extensive downstream processing required
Fourth generation
Genetic Engineering
Biofuel
Higher lipid content
CO₂ capture
economical in long run

(b)


Light passenger vehicles
Road freight
Shipping
Aviation
Million Liters
0
20
40
60
80
100
120
140
160
66
12
82
37
4
124
59
9
16
151
82
15
31
2015
2020
2025
2030

(c)

Fig.6 (a) Global biofuel production in thousand metric ton of oil equivalent (b) Biofuel production efficiency for 1st , 2nd, 3rd, 4th generation [76](c) Estimated biofuel consumption in automotive sector up-to 2030.

4. Biofuel Electric-vehicles (BEV) Technologies over existing energy storage systems

The world continues to strive to find different clean (renewable energy) sources to run millions of vehicles on the road every day. These vehicles can reduce the toxic emissions significantly [13, 52-55]. This section presents a summary of current landscape of the biofuel electrical vehicle technologies [77].

4.1 Limitations of existing batteries for the automotive industry

A biofuel cell has many advantages over existing conventional batteries. Biofuel cells are more efficient than diesel or gas engines. Most fuel cells run silently compared to internal combustion engines. Biofuel cells do not need conventional fuels such as oil or gas and, therefore, can reduce economic dependence on oil-producing countries, creating greater energy security. One of the main disadvantages of battery electric vehicles (BEVs) is that the limited energy capacity of the batteries means that the vehicle's range is less than that of a conventional vehicle [78, 79]. With the ability to carry more energy in the vehicle, the advantages of a biofuel fuel cell (FCV) begin to be evident. The use of fixed biofuel cells to generate power at the point of use allows a potentially more stable decentralized electricity network. Low temperature biofuel cells, such as the proton exchange membrane and the direct ethanol fuel cell (PEMFC, DMFC) have low heat transmission, which makes them ideal for military and transport applications. Unlike batteries, biofuel cells have no "memory effect" during refueling. Biofuel cell maintenance is simple as there are few moving parts in the system [13].

In the following sections, biofuel cell electric vehicles (FCEV's) were compared to the battery powered electric vehicles (BEV's) on the scale of weight, volume, greenhouse gases and cost.

4.1.1 Vehicle weight

Biofuel cells (BFCs) can supply electricity to a traction motor for vehicles weighing 8 to 14 times lesser than current batteries. According to the US Advanced Battery Consortium report, electric vehicles weigh more than BFCVs for a mentioned range, as shown in Fig. 6a. Fig 6a is based on a Ford high intensity aluminum vehicle saber with a BFCEV test weight of 1280 kg, drag coefficient of 0.33, frontal area of 2.127 m^2 and rolling resistance of 0.0092. As shown, the additional weight to increase the autonomy of the EV biofuel cell is negligible, while the weight of the EV battery increases significantly for intervals in excess of 100-150 miles due to the weight composition. Each additional kg of battery weight to increase the autonomy requires an additional structural weight, a larger traction motor, heavier brakes, and in turn, more batteries to carry this additional mass, etc. [14].

4.1.2 Storage capacity

The main concerns of some analysts are about the tank volume required for hydrogen and compressed gas. In fact, they need more volume than the gas tank, but compressed hydrogen tanks take up much less space than batteries. The hydrogen system has an intrinsic advantage in the basic energy density but this advantage is amplified in a vehicle due to weight gain [80]. Therefore, the EV battery requires more energy stored per mile than the BFCEV due to the heavier batteries and the resulting heavier components. The space for storing lead-acid batteries would prevent a full five-passenger vehicle with a radius of over 150 miles, while the NiMH would be limited in practice to less than 200 to 250 miles [81]. An electric vehicle with an advanced lithium ion battery could, in principle, reach a range of 250 to 300 miles, but these batteries would occupy 400 to 600 liters of space. The fuel cell with hydrogen storage tanks would occupy less than half of this space and if DOE's hydrogen storage targets were reached, the hydrogen tanks would occupy only a volume of 100 liters in a range of 300 miles [80].

4.1.3 Greenhouse gas pollution

The implications of GHGs on recharging battery-powered electric vehicles with the current network are serious. Greenhouse gases would be much higher for electric vehicles than for hydrogen powered FCEVs, assuming that most of the hydrogen was formed by reforming natural gas over the next decade or so. The increased weight of the EV to reach a reasonable range of the vehicle increases fuel consumption as the vehicle becomes heavier. The impact on GHG with the marginal mix of today's network is shown in Fig. 6(b). The hydrogen FCEV that works with the hydrogen is derived from natural gas and can reach the range of 300 to 350 miles without sacrificing GHG reductions and would immediately reduce GHG emissions by more than 50% compared to normal cars. This greenhouse gas calculation includes all "well equipped" greenhouse gases suitable for an atmospheric life of 100 years. From this analysis, the EV autonomy of a passenger battery would be limited to about 60-70 miles before the EV with lead batteries would generate more net GHG than the petrol version of the same car generating around 480 g / miles. The non-net GHG increase range for a NiMH EV battery would be between about 125 and 150 miles [18, 82, 83].

4.1.4 Cost

Kromer and Heywood at MIT [14] did a cost analysis of several alternative vehicles in mass production. They concluded that an advanced EV battery with a range of 200 miles would cost about $10,200 more than a conventional car in 2030, while a BFCEV with a range of 350 miles will cost only $3,600 more in mass production [84].

4.2 Advancements in BFCs

Some advancements carried out in the development of sustainable energy derived electric vehicle technologies are discussed in the following sections:

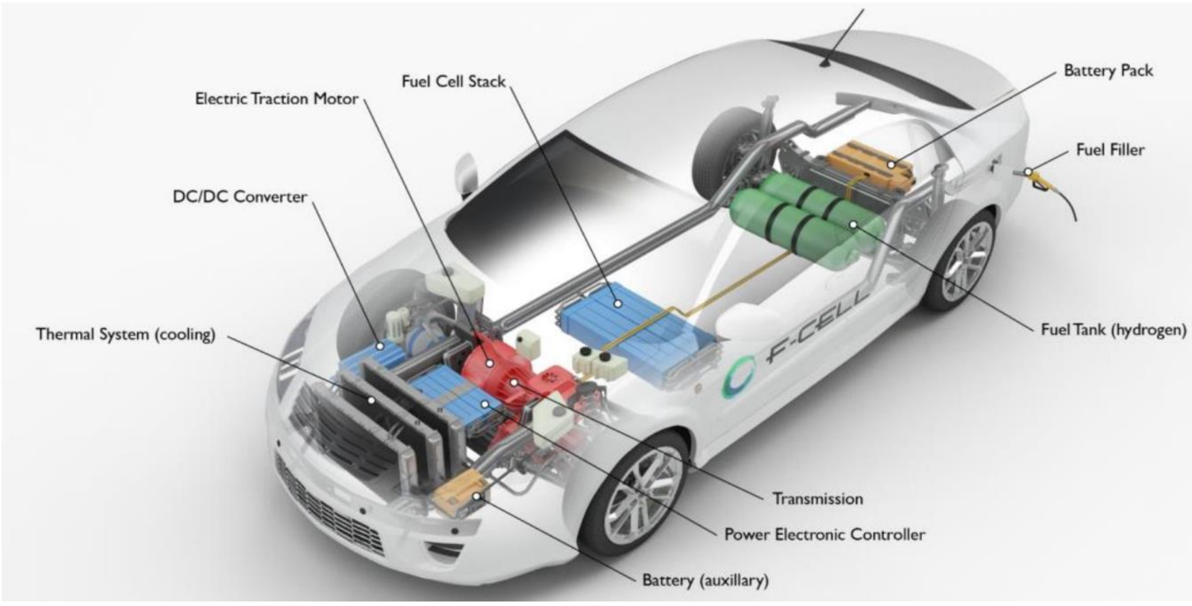
4.2.1 Development of hydrogen fuel electric vehicle (HEV)

Hydrogen (H_2) is the simplest form of all molecules; It has the lowest energy content in volume but has the highest energy content of any fuel by weight. It is available in the atmosphere as a gas and water. It is used as a fuel in applications such as FC and missiles due to its high energy content of H_2 [85]. Its major advantage over fossil fuels is zero harmful emissions and that the heating value of hydrogen is three times larger than that of petroleum oil. Various carmaker companies like Honda, Toyota and Hyundai have started producing fuel cell vehicles/cars (FCVs) with hydrogen as fuel. Over 6500 FCVs were sold to consumers in June 2018. Currently, California is the leading market for FCV because this state hosts the largest network of hydrogen fueling stations in the world and nearly 5233 vehicles were sold throughout the world. FCVs have autonomy of over 300 miles and can refuel in less than 10 minutes at a hydrogen filling station. It has a greater potential for use as a fuel in the future and it has been estimated that by 2030, the cost of fuel cells will be competitive with ICE's based on technological improvements and their availability would also improve [86, 87].

4.2.2 FCV model for hydrogen storage

One of the main concerns for the development of FCV is hydrogen storage. Now researchers are actively working on the development of hydrogen storage systems to meet customer needs by introducing new methods as described in sections 4.3.2.1 and 4.3.2.2. It is difficult to keep a vehicle onboard sufficient to achieve an adequate driving range without the storage container is too large or too heavy because of its low energy density. Fig. 7 (a) shows a hydrogen FCV with onboard storage of compressed gas [86].

In this model, pressurized tanks have impact resistance for collision safety with sufficient strength and this is made with cylinders wrapped in carbon fiber. This tank is structured that maintains a pressure of 34 MPa with a mass of 32.5 kg and a volume of 186 L of compressed hydrogen, and this is suitable for a 500 km drive. It has a tank volume of about 90% of a 55-gallon drum, which is great for individual cars. In the following sections, some changes in vehicle architecture are discussed to overcome existing issues of the FCV model [88].



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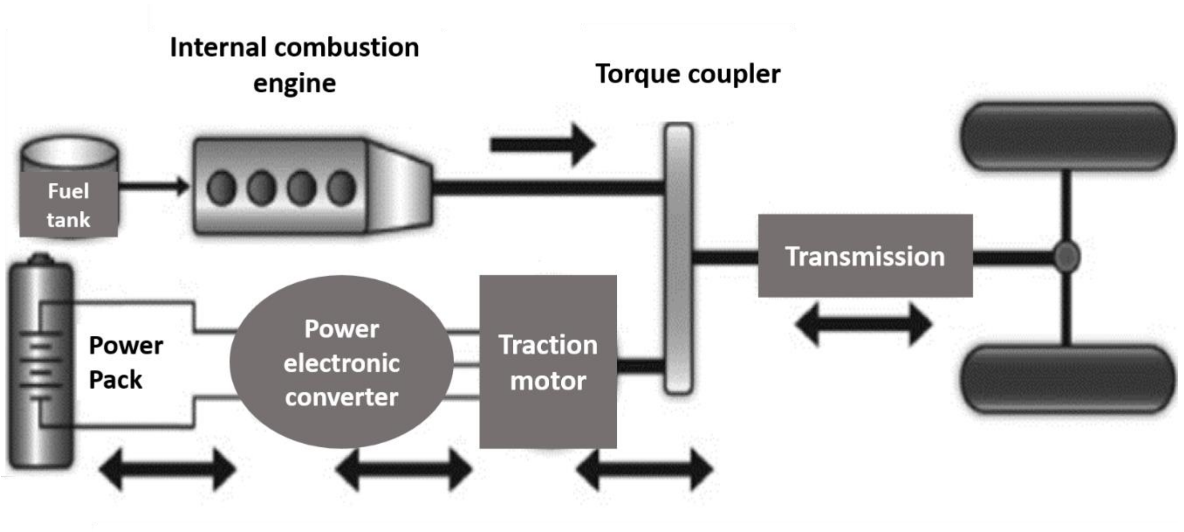

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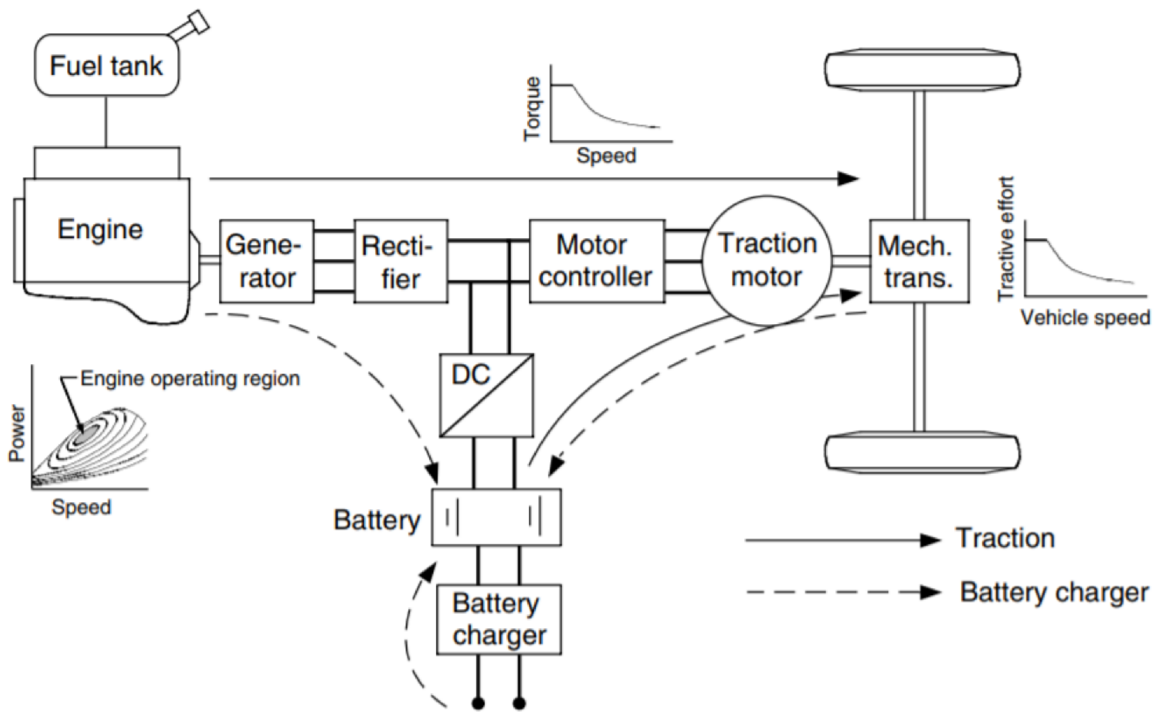


(c)

Fig. 7 (a) Bio-fuel cell vehicle with on-board storage (b) Parallel hybrid configuration (c) Series hybrid configuration [86]

4.2.2.1 Parallel Hybrid

One of the earlier hybrid drive train designs was the parallel hybrid architecture. In this configuration, both the internal combustion engine and the electric motor can be used to power the vehicle independently of one another. The ICE has low torque output at low speeds, therefore in stop-and-go drive cycles, an ICE is extremely inefficient. However, electric motors provide almost instantaneous torque, making them ideal for stop-and-go drive cycles. Implementing a parallel hybrid system allows each power source or both to operate at varying degrees when it is most efficient in the drive cycle (Fig 7b) [86, 89].

4.2.2.2 Series Hybrid

A series hybrid drive train architecture differs from a parallel hybrid drive train in that the two power sources are no longer independently able to power the vehicle. In this configuration, generally, the ICE will act as a charger for the batteries that supply electricity to the electric motor—the only source to propel the vehicle. One of the advantages of this design is that there is no need for transmission since, ICE does not power the vehicle directly. Eliminating the transmission from the engine system reduces the weight of the vehicle, which directly correlates to increased efficiency [90]. In a series configuration, the ICE does not have to account for any of the transient dynamics in the drive cycle as it would in a parallel configuration. Due to this, the engine can be operated at a steady state at its most efficient rpm, further increasing its efficiency (Fig. 7c) [67, 68].

4.3 Problems and challenges in successful implementation of biofuel cells

Today, biofuel electric vehicles (HEVs) have gained considerable interest among manufacturers since they started entering the automotive industry on a large scale. The problem of GHG emissions has been also solved by car manufacturers and researchers with these types of vehicles [91-93].

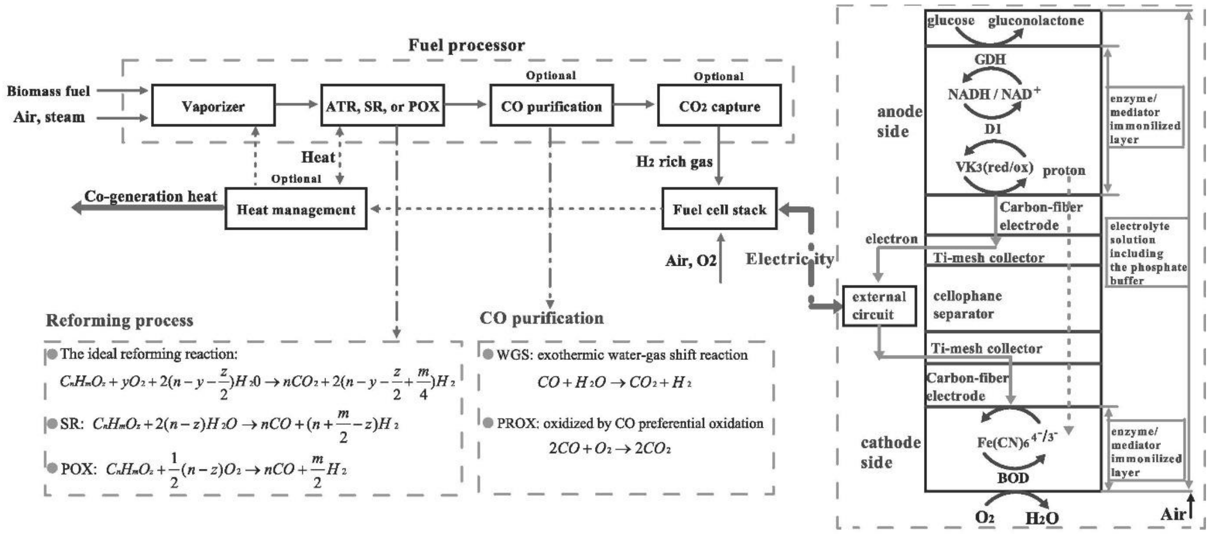


Fig.8 Fuel processor and reaction scheme for biofuel cells [28]

The reaction scheme for the existing biofuel cells is shown on the right in Fig. 8. Fuel cells coupled with biomass-derived fuel processors could be considered one of the most promising energy supply systems in the future. These fuel cells can convert renewable energy into an environmentally friendly CO_2 neutral energy source. Biomass-derived fuels, such as ethanol, methanol, biodiesel, glycerol, and biogas, are fed into a fuel processor as raw fuel, which is then reformed through auto thermal reforming, steam reforming, partial oxidation, or other reforming methods [94]. In a fuel processing system, the most important element is the fuel reformer, which converts the fuels into a hydrogen rich gas. A vaporizer is required to preheat the fuels, steam, and air before they are fed into the reformer. After the reforming process, CO purification and CO_2 capture are possible, after which the purified H_2 rich gas is fed into the fuel cell to generate electricity. Higher system efficiency can be achieved using combined heat and power generation systems (CHP), with the overall system fuel utilization exceeding 90% [95]. The "fuel processor-fuel cell CHP system" allows better control of the mass and thermal conversions as it has a superior thermal balance. As the development of biofuel cells for practical applications is still in its infancy, significant market penetration is expected to take a long time as there is significant potential for further improvements.

The development of an optimal BFCEV requires many considerations in terms of proposals and dynamics of its model, as well as a careful estimation and selection of parameters and dimensions to ensure that an efficient FCHEV is proposed. Some of the problems had been fixed by changing vehicle architecture as discussed in the previous section and it is also expected that the BFCEV introduced in the market will be able to compete with conventional ICEs that have proven to be reliable in terms of performance and autonomy. Still, there are challenges faced by FCHEV marketing, which are analyzed and elaborated in this section alluding to the new e-biofuel cell systems [96, 97].

Considerable research has been conducted on FCEVs. Some studies have not only been simulated but also extended to the application in real time or verified by an experimental configuration. Uncontrollable hydrogen consumption in FCHEV increases operational or maintenance costs. The high cost of FCHEV can affect the perception of end users who prefer to buy conventional ICE vehicles instead of an FCHEV simply due to the more economical option. Therefore, further research is required to study these limitations which were not considered in previous studies [98].

Table 2: Comparative analysis of ICE, BEV and FCEV [28]

	Conventional Gasoline Vehicle (ICE)	**Battery Electric Vehicle (BEV)**	**Fuel Cell Electric Vehicle (FCEV)**
Power Source	Internal combustion engine Gasoline	Rechargeable battery Electricity	Hydrogen fuel cell Hydrogen
Existing Infrastructure	Widespread/ubiquitous	Limited, but extensive near-term expansion	Very limited with targeted near-term expansion
Performance	-Highest drining range -Best top speed and refueling time -Only service interval shorter	-Limited energy storage capacity and driving range -Refueling time in order of hours	-Similar range to ICE -600km average driving range -Refueling only takes couple of minutes -Fewer service needed

		-Ideally suited to smaller cars and urban driving	
Environment	-Highest CO_2 and local vehicle emissions -Unlikely to meet EU CO_2 reduction goal for 2050	-High CO_2 reduction (~80%) if CCS or renewable energy is used -Depends on electricity footprints -No local vehicle emissions	-High CO_2 reduction (~80%) compared to today with CCS and water electrolysis -No local vehicle emissions -Lowest carbon solution for large cars
Economics	-Most economic vehicle -Lowest purchase price -Higher fuel or maintenance cost -Existing infrastructure	-Economic for smaller cars -Purchase price higher than ICE -TCO higher than ICE TCO -Fuel cost comparable to ICE	-Purchase price is higher than ICE -TCO comparable to ICE for larger cars, not smaller cars -Infrastructure cost comparable to BEV
Biofuels	Source alternative: Biofuel Low CO_2, if 100% biofuel	Source alternative: Bioelectricity Biomass→Bioelectricity	Source alternative: Hydrogen Biofuel→Hydrogen

It seems idealistic and very promising to introduce and market hydrogen as a vehicle fuel resource. Real implementations are far more complicated. The primary problem when using an FCHEV is that there is not easily accessible hydrogen as a fuel resource [99-103]. There are only a few hydrogen refueling stations or infrastructures globally accessible [104-109]. Pipes with new valves and compressors are required for hydrogen distribution and storage problems are another concern for this fuel because of its low energy density [110, 111] [103-105]. So, extended radius FC storage tanks are required. Volumetric energy density can be increased by storing hydrogen under extremely low temperatures and extremely high pressure [112-116]. Hydrogen gas must be compressed at pressures between 350 and 700 bar, thus allowing an adequate tank size for FCHEV. So, hydrogen production must be transferred to renewable resources, such as water electrolysis, to reduce greenhouse gas emissions. H_2 refueling infrastructures must also be planned and well developed before wide scale production of FCHEVs [117-120]. Table 2 differentiates traditional petrol vehicles (ICE) from electric vehicles based on battery (BEV) and hydrogen fuel cell electric vehicles (FCEV) in terms of sources of Energy, performance, economy, existing infrastructure and environmental impact for better comparative understanding [80, 121, 122].

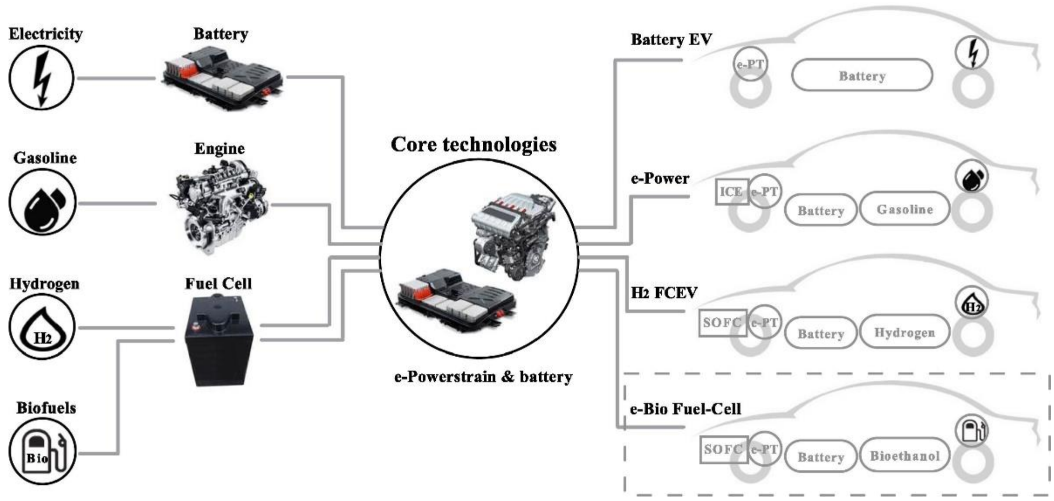
4.4 Development of new e-Biofuel cell system

Development and implementation of fuel cell vehicles and infrastructure for hydrogen fuel in electric vehicles are still at an early stage for real world transportation applications. However, a new e-Biofuel cell system is developed by Nissan Motor Co., Ltd., which has overcome the common obstacle of the traditional fuel cell vehicles like the lack of infrastructure for the supply of hydrogen. The e-Biofuel cell is a system powered by a solid oxide fuel cell that uses bioethanol as an on-board hydrogen source (Fig. 9) [28, 123].

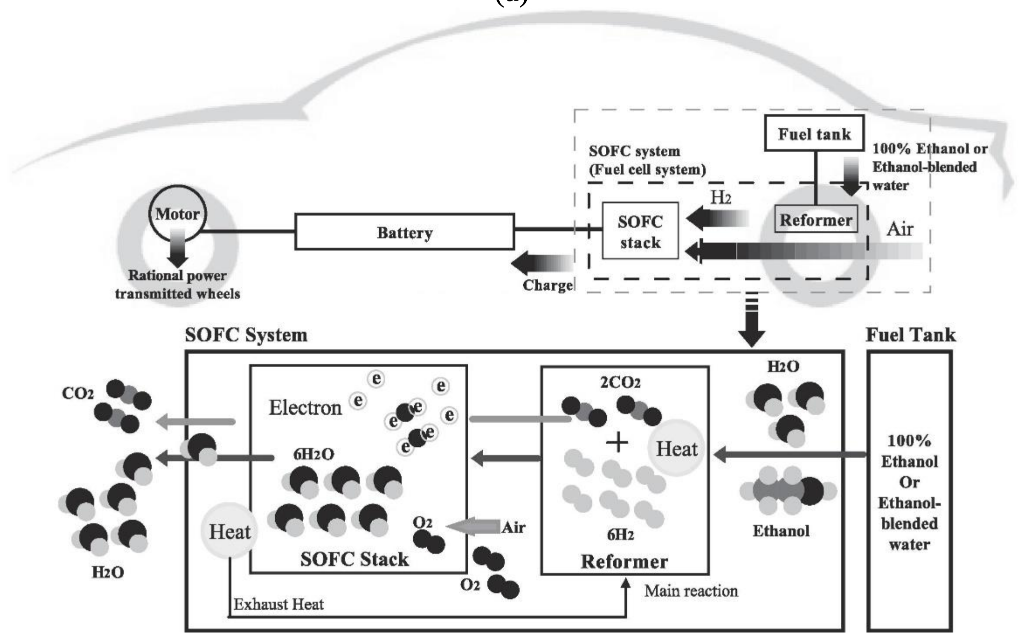
Nissan Motors featured a SOFC stack [94, 124] and an integrated refinement to convert 100% ethanol or H_2O (55%) mixed with ethanol (45%) in H_2. This new system can easily work 24 hours a day, 7 days a week, offers silent driving and a short refill time, and costs equivalent to those of electric vehicles when using mixtures of ethanol and water. Generation of H_2 in this biofuel system can be presented by this reaction:

$$C_2H_5OH + 3H_2O \longrightarrow 6H_2 + 2CO_2 \quad (3)$$

Solid oxide fuel generates electricity through a reaction of H_2 with oxygen from the air. Oxygen ions move through the electrolyte of the fuel cell, generating energy [125, 126]. One of the main advantages of this high temperature operating system is, that a highly active catalyst is not required. In this SOFC bioethanol system, CO_2 emissions can be recycled into raw materials which means this system works almost without increasing CO_2. Nissan has stated that in the future e-Biofuel cell will be even easier to use. Water mixed with ethanol is easier and safer to handle than most other fuels [127-129].



(a)



(b)

Fig. 9 (a) New e-Bio Fuel Cell system (b) e-Bio Fuel-Cell is a fuel cell system that uses bioethanol (100% ethanol or an ethanol-blended water) as a fuel source to generate electricity through the Solid-Oxide Fuel Cell (SOFC) [28]

5. Environmental impact and sustainability in the transport sector

In regional and global areas, environmental and sustainability problems cover a growing range of pollutants, degradation factors of ecosystems and dangers. Some of these concerns were derived from observable chronic effects, for example in human health, while others were derived from real or perceived environmental risks, such as the possible accidental release of hazardous materials.

The environmental impact is associated with the use of energy resources. Ideally, a company that seeks sustainable development uses only energy resources that release minimal emissions into the environment and, therefore, cause little or no environmental impact. However, since all energy resources can somehow cause a certain environmental impact, increased efficiency can somehow alleviate concerns about environmental emissions and their negative impacts [110].

5.1 Current scenario of biofuel vehicles

European Union has recently introduced ambitious plans to reduce carbon emissions from new trucks and buses by 30% as part of their commitment to reducing their carbon footprints.

European funds, as well as national and regional government funds, are set to deliver nearly 300 fuel cell electric buses (FCEBs), including hydrogen refueling stations in 22 European cities by 2023. Continuing with the commitment, the Federal Transit Administration has financed $90 million national fuel cell bus program, including LoNo (low or no emissions distribution) [130, 131].

Asian countries are also focussed on biofuel vehicle development. China has also set great ambitions under their five-year target of operating 75% of public services with green energy and plans to use several thousand buses in the larger cities by the end of 2022. Korea, historically a strong proponent of hydrogen, although more recently focused on fixed fuel cells, has returned with major projects.

5.2 Environmental sustainability

Biodiesel and its derivatives prepared by blending up to 20 percent can be used in diesel engines. However, it should be kept in mind that biomass-based diesel alternatives can increase certain emissions that causes air pollution. Unlike petroleum-based fuels, biofuels are readily biodegradable. Accidental spillage of biofuels would have minimal impact on wildlife and the environment. They also claim that biofuels burn more cleanly and completely, resulting in less pollution because fewer oil contaminants are released into air and water [132].

Currently bioethanol biofuel is used at a large scale. In the USA over 1.5 billion gallons are added to gasoline each year to improve vehicle performance as well as to reduce air pollution. For years, scientists have produced and tested biodiesel fuel, transformed vegetable oils or animal fats into diesel fuel, as an alternative to petroleum-based diesel fuel or "petrodiesel". Biodiesel production is continuously growing in the United States and is estimated to be around 30 million gallons per year [133].

5.3 Economic sustainability

According to the renewable fuel standard (RFS), biofuels should contribute significantly to renewable energy in the coming decades. These fuels offers energy independence, rural development and reduced carbon emissions. However, several environmental and economic problems remain unsolved. From environmental perspective, most of the biomass should come from the expansion and / or intensification of agriculture, which can significantly impact the net and economic environmental impact. Biofuels have potentials to offer a new market, income opportunities and economic growth in rural areas. Reducing dependence on fossil fuel imports and obtaining fuel from various biomass raw materials has also helped stabilize transport costs in Europe [134].

The biofuel industry can create around 6,000 operational jobs each year, more than 38,000 low-skilled jobs a year (to pack and transport agricultural waste), while more than 26,000 people could potentially be employed in the transport sub-sector by 2030 every year. Palm biofuel production also offers new economic opportunities for most people in rural communities in developing countries. Oil palm cultivation and milling of palm oil offer people ample opportunities in terms of job creation, investment opportunities, etc. Oil palm biomass is an economic source of raw material for palm biofuels compared to other raw materials used for the production of biofuels. The production of bioethanol and biomethane from palm oil biomass is also profitable [28, 135].

As a core component for socioeconomic system interactions and development, transportation sustainability has become an increasing research interest because of the linkages between environmental protection, economic efficiency, and social progress [136]. Therefore, vehicles such as EV and FECV are viable transport alternatives for the implementation of new engine and new energy sustainability improvements. Fuels can also be improved through the use of alternatives such as biofuels, electricity, or hydrogen [137, 138]. In this paper, through the examination of transport biofuels and the above analysis, a sustainable transport paradigmatic structure within a dynamic framework was developed from an energy, environmental, and conversion perspective, as shown in Fig. 11.

Table 3: Fuel economy of various types of vehicles [30]

	Company/Brand	**Car design**	**Fuel Economy, MPG**

Fuel Type			**City/Hwy**	**Combined Mode**
Diesel Vehicle	Volkswagen Golf		30/42	34
Gasoline Vehicle	Ford Focus FWD		27/38	31
Flexible Fuel Vehicle	Ford Focus FFV		20/28	23
Fuel Cell Vehicle	Honda Clarity		60/60	60

In essence, the biofuel economy is a central factor in determining BTW energy consumption (wheeled biomass) and GHG emissions associated with a biofuel vehicle system. Highway mode, city mode and combined mode are the three main types of fuel economy of a vehicle [38, 39]. City mode indicates that a vehicle leaves in the morning after being parked at night and driving at a traffic stop in the urban area. The motorway mode is a mixture of rural and interstate driving in a heated vehicle, which represents a typical longer journey in free traffic. Combined fuel economy is based on a combination of the two modes mentioned above. Four types of economies have been shown in Table 3 namely petrol/gasoline vehicles (GV), diesel vehicles (DV), flexible fuel vehicles (FFV), and fuel cell vehicles (FCV)[40]. The fuel consumption for FFV is lower than that of the GV type, generally around 25%. The DV selected for comparison was the Volkswagen Golf, which has a fuel economy of 34 mpg in combined mode [43] and many other operating characteristics[139]. In this work, the Honda Clarity [140] was selected for life cycle analysis. As shown in Table 3, the fuel economy for the FCV is considerably greater than that of the GV because the energy efficiency of the fuel cell engine is significantly greater than that of the ICE.

6. Global forecast and Government's policy over biofuels

Biofuel has enormous potential to generate employment for rural areas development. Environmental benefits and energy security are key factors that work for biofuels. There has been a positive shift towards the growth of biofuels as a source of energy due to subsidies and incentives offered by the Indian government for instance. Bioethanol has been assigned a special tax at favorable conditions of 16 percent and is also exempted from the special tax [141]. Currently, there are no other taxes and central taxes proposed or planned for biofuel collection [142, 143].

6.1. Indian Government approach

India's approach to the biofuels sector has been different from the current international approach, as India's focus has been on raw materials raised on degraded lands or wastelands, thus avoiding fuel conflicts faced with food security. India's biofuel policy favors the use of indigenous biomass food reserves for biofuel production. The policy objective was to ensure that a minimum level of biofuels was readily available in the market to meet the demand at any time. India aims to achieve 20 percent blending of biofuels, both for biodiesel and bioethanol, so that the country will have to produce 6.7 billion litres of ethanol by 2021 and 9.1 billion litres by 2030 [144, 145].

To make fuel safety problems independent of food safety in the Indian context, the development approach consists of using waste, degraded forests and non-forest and only for the cultivation of shrubs and non-edible oilseed trees for the production of biodiesel fuel. Price dependence should be resolved in such a way that the future growth of biofuels is not hindered by the increase in the price of oil. At present, the minimum purchase price (MPP) of biodiesel is linked to the current retail price of diesel and is based on the actual cost of production and the import price of bioethanol [59].

As yet, important political reforms are needed to hide the induction of innovation and strategies to expand dissemination and provide investors with access to capital through the development and adaptation of technology [83].

6.2. Approach of other governments

Global biofuel production has started to increase in recent years. An estimation of the global consumption of biofuels which was 18 Megatons of oil equivalent (Mtep) in 2004, is estimated at 140 Mtoe in 2030 (VIA, 2013) [59, 146]. The biofuel-based automotive market is growing rapidly, paving the way for China, European and American markets to grow steadily. Countries like India are already aiming for full electrification of the vehicle fleet by 2040 [147, 148].

Further, in this section we discussed i) the challenges that restrict flexible, reliable and cost-efficient market uptake of advanced biofuels for transport, and ii) highlight policy interventions that are relevant to current policy, Green Deal and Sustainable Development Goals (SDGs) [149] and have strong potential to overcome the challenges reported by Panoutso et al.[150] . In their research, they firstly rationalise the role of advanced biofuels in the current markets, a second analysis was done on policy relevant challenges that prohibit market uptake of advanced biofuels, discusses associated policies and performance towards flexibility, reliability and cost. The third presents policy interventions that can overcome challenges and are relevant to current policy and Sustainable Development Goals. Finally, the fourth provided the concluding remarks for future policy as well as focused on advanced biofuels from lignocellulosic feedstock that will safeguard issues with and use changes. An individual analysis is included for the aviation, marine and heavy-duty road sectors [61, 151].

6.3. Challenges and policy related gaps

This section analyses policy relevant challenges that prohibit market uptake of advanced biofuels and discusses associated policies and performance towards three competitive priorities: flexibility, reliability, and cost [152, 153]. Flexibility is required in advanced biofuel value chains for handling various feedstocks and/or adjusting conversion process parameters to produce a variety of products, in future multi-product biorefineries. Reliability focuses on feedstock and process consistency and fuel quality throughout the operational life of a value chain. Cost is the most difficult challenge that advanced biofuels [144] face in their competitiveness with fossil fuels and renewable electricity-based energy carriers which are (or are expected to be) available in the market during the 2020–2030 timeframe. In this context, Table 4 provides an overview of policy relevant challenges across the value chain stages and grades their risk to hinder the performance in terms of flexibility, reliability and cost.

Table 4: Policy relevant challenges for flexibility, reliability and cost of advanced biofuels and their risk towards market uptake for 2030 [150].

	Flexibility	**Reliability**	**Cost**
Biomass supply			
Agriculture & forest residues	Soil carbon loss	Biodiversity loss	Disperse, low density, ununiform material
	Competing markets	Nitrogen leaching due to overharvest	Competing markets
Lignocellulosic crops	Spread of invasive species Degraded land improvement	Direct & indirect land use change	Low yield (high production cost per unit) in degraded land
Organic wastes & lipids	Limited bulk availability	Variable quality	Collection and sorting
Conversion pathways			
Fermentation	Co-location with existing infrastructure	Establishing adequate operational capacity by 2030	Establishing adequate operational capacity by 2030
			Process efficiency, especially for butanol production
			By-products utilisation (e.g., lignin fraction)
Gasification		Gas conditioning and clean up	
		Co-location	
		Capacity redundancy required for First-of-A-Kind plants	Uncertain production costs
Pyrolysis	Pyrolysis oil upgrading and/or coprocessing	Catalysts with improved selectivity and stability for pyrolysis oil upgrading are not yet commercial	Pyrolysis oil upgrading and/or coprocessing
Upgrading and hydrotreatment	Co-location with existing infrastructure	Establishing adequate operational capacity by 2030	Establishing adequate operational capacity by 2030
			Process efficiency, especially for butanol production
			By-products utilisation (e.g., lignin fraction)
End Use			
Aviation	SAF must be drop-in	Competition with biodiesel production	International competition with non-EU operators
	Blending restricted to 50% (safety and lubricity restrictions)	Fuel quality critical to ensure safety in the air – variations in fuel quality dependent on conversion and feedstock	Fossil kerosene cheaper than all certified SAF pathways

	Lower aromatics content in some of SAFs might lead to jet engine compatibility issues (older engines)		Upgrading of bio-oil/biocrude leads to increased final price
Marine	Competition with biodiesel production	International competition with non-EU operators	
	Existing fuel infrastructure, no engine modifications	Access to renewable raw materials	International competition with non-EU operators
	Ensuring compatibility of new fuels or their blends & blending behaviour	Fuel quality of less refined fuel should enable year-round operation	Low prices of HFO, MGO
	Dedicated infrastructure needed onboard as well as in harbour (in case of methanol or LBG)	High fuel volumes needed for single vessel – risk of advanced biofuel seasonal shortage	Loss of cargo space due to bigger fuel tanks
	Multi fuel blends increase complexity		
Road	Use of existing fuel infrastructure, no engine modifications	Access to renewable raw materials	International competition with non-EU operators Need of compensation for lower income end-users
	Infrastructure and engine modifications needed for higher alcohols or FAME blends.	Shortage of sustainable feedstock for HVO or ethanol production	Price gap between advanced biofuels and fossils
	Completely new infrastructure for DME or hydrogen		End-user choosing economically justified option

6.4. *Policy interventions relevant to current policy to achieve Sustainable Development Goals (SDGs)*

As reported by C. Panoutsou and research group [150], current policy mechanisms have established targets and monitoring frameworks for low carbon fuels and improved car engine performance but have not yet been adequate to facilitate the market uptake of advanced biofuels [154, 155]. Their efficient market roll-out must be immediate if the 2030 targets are to be met. Analysis within this section reiterates that their future deployment, in market shares that can lead to decarbonisation, still depends largely on the integration of tailored policy interventions that can overcome challenges and improve upstream and downstream performance [156, 157]. Policy, integrated across the value chain, can facilitate the future market uptake of good quality and sustainable advanced biofuels that are compatible with current vehicle engines and infrastructure for producing, storing, transporting and retail stations. Tailored policy interventions integrated along advanced biofuels value chain (feedstock production, conversion, end use) are essential for future policy format at all governance levels [158, 159]. On one hand, these must target to meet the challenges that have been identified as hurdles to the sustainable development of the value chain stages and individual market sectors and on the other hand should facilitate sector integration and alignment with the principles of Green Deal and the Sustainable Development Goals [160, 161]. This will increase investors' confidence and allow industries to improve their technical and financial performance. Tailored financing mechanisms (such as feedstock premiums, feed in tariffs and premiums, CO_2 taxes, etc.) are necessary to de-risk the capital investment and ease uncertainties in the production costs. Since many of these fuels with strong future potential (i.e. methanol, DME), needs dedicated powertrains engine, infrastructure modifications need to be considered alongside the fuel production costs [162, 163]. Changes associated with investments in dedicated engine R&D, upscaling of production lines, distribution network, logistics, etc. are inevitable, therefore, consistent and long-term policy support is urgently needed [164-166].

7. Conclusion and future directions

Today the world is facing an acute energy crisis, which is steered by our over reliance on fossil fuels. This article shows new hopes to overcome the foreseeable problems which would otherwise be a direct result of this crisis. In a timely effort, the review brings fresh discussions and insightful commentary on the prospects and current status of biofuels. Figure 10 shows how the future transport roadmap will make the 21st Century transport more sustainable and resilient.

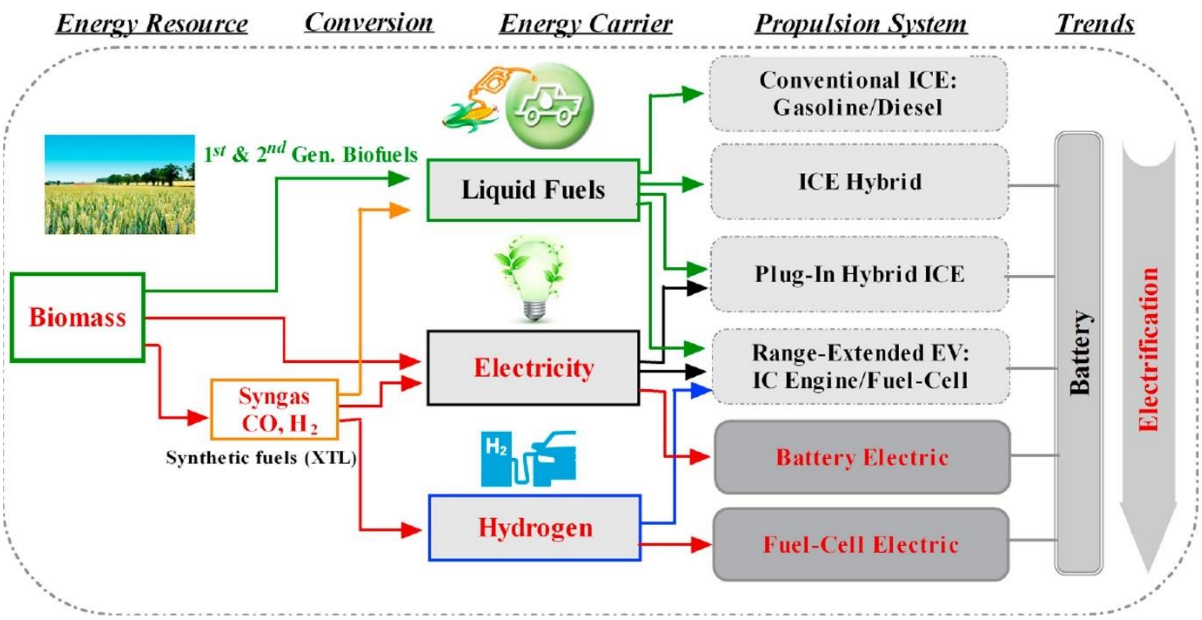


Fig 10. Technology roadmap for future bioenergy transport [28]

Techno-commercial scenarios of producing biofuels from feedstocks including bioethanol, biohydrogen, and biodiesel were reviewed and it was seen that algae-derived biofuels can change the course of the future. It was observed that global biofuel production will continue to be supplied predominantly by traditional feedstocks such as sugarcane and maize for ethanol and various vegetable oils for biodiesel production. Biodiesel produced from used cooking oil will continue to play an important role in the European Union, Canada, USA and Singapore. World biodiesel trade is projected to decrease by 25% from current levels, largely reflecting declining demand for palm oil-based biodiesel in the European Union; ethanol trade will decrease moderately.

Moving towards a prospective future, the article shows better prospects of biofuel cells over a battery based on the fact that biofuel cell outbids a battery in terms of energy capacity. Work in this direction has started to show promise. For instance, low temperature biofuel cells, such as the proton exchange membrane and the direct ethanol fuel cell (PEMFC, DMFC) have low heat transmission, which makes them ideal for military and transport applications. Also, as opposed to batteries, biofuel cells have no “memory effect” during refueling.

Recently, a major automotive company Nissan has come up with a stack of solid oxide fuel cells which can work 24X7 while offering silent driving and a short refill time, and costs equivalent to those of electric vehicles when using mixtures of ethanol and water. This generates electricity through a reaction of H2 with oxygen from the air. Nissan has stated that in the future e-Biofuel cell will be even easier to use.

A major infrastructure need is a seemingly big ask to set up new refueling stations for the safe generation, storage and transport of hydrogen. It is expected that additional training exercises for common people may be required to make them aware of the hazards that hydrogen and alike gases can pose. It was also seen that flexibility is required in advanced biofuel value chains for handling various feedstocks and/or adjusting conversion process parameters to produce a variety of products, in future multi-product biorefineries. Finally, more reliability is required in feedstock and process consistency and fuel quality throughout the operational life of a value chain. Cost competitiveness is the most difficult challenge that advanced biofuels face when compared to traditional fossil fuels, however, with the world setting a stiff target to achieve ‘net-zero’ by 2030, the scale of economy is expected to be achieved which would help common people to easily afford biofuels.

CRediT authorship contribution statement

J. Verma: Conceptualization, Methodology, Investigation, Data curation, writing – original draft, **S. Goel**: Review, editing & supervision

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Statement

As this is a review paper, no new data was generated.

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