Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

Study the Effects of Automobile Emissions on the Environment and the Advancement of Electric Vehicle Technology

Hailegebrel Zewdie Woldetensay, Dinku Seyoum Zeleke
Department of Mechanical Engineering Addis Ababa Science and Technology University,
Addis Ababa, Ethiopia

Getachew Shunki Tibba
Menschen fuer Menschen Foundation Agro Technical and Technology College. Ethiopia

Abstract
Automobile emissions have a significant environmental impact, contributing to air pollution, climate change, and other environmental issues. Minimizing the effects of climate change and reducing dependency on fossil fuels are the two major problems facing the car industry today. Several methods are being considered to resolve these problems. Among these are the adoption of electric cars, better engine design, and the transition to ecologically benign alternative fuels. Electric vehicles (EVs) are a potential solution to this problem, as they emit no tailpipe emissions. However, the environmental impact of EVs is not entirely clear, as they also have a carbon footprint associated with their production and use. Electric vehicles (EVs) can reduce automobile emissions more effectively if they are powered by electricity generated by renewable energy, avoiding pollution caused by generating stations that use fossil fuels. As a result, renewable energy's position in the transportation sector is critical. This paper examines the environmental impact of automobile emissions. It also provides a brief overview of the development of EVs. The review concludes that EVs have the potential to drastically lessen the environmental impact of transportation, but more research is necessary to fully comprehend this impact as well as to overcome the obstacles related to their development and implementation.

***Keywords*: Environmental degradation, Alternative fuels, Greenhouse gases, Emission, Pollution control, Electric vehicles**

1. INTRODUCTION

The automobile industry, together with other related sectors, employs the majority of working people and is the foundation of the global economy. The question arises because the vast majority of automobiles in the world have internal combustion engines and run on either gasoline or diesel fuel. On the one hand, there is a growing scarcity of oil resources. This can be attributed to the fact that a great deal of countries still rely mostly on fossil fuels for electricity and fuel for transportation[1]. However, as the world's population grows, there will be a greater proportion of fuel-consuming automobiles.

It is projected that there will be nine billion people on the planet by the year 2050, which means there will be a substantial increase in fuel supply to meet potential energy demands. According to the BP Statistical Assessment, global proven oil reserves reached 1733.9 billion barrels in 2019, enough to satisfy just 50 years of global energy demand. Fig. 1 shows how proved oil reserves are distributed globally as of the end of 2019 [1].

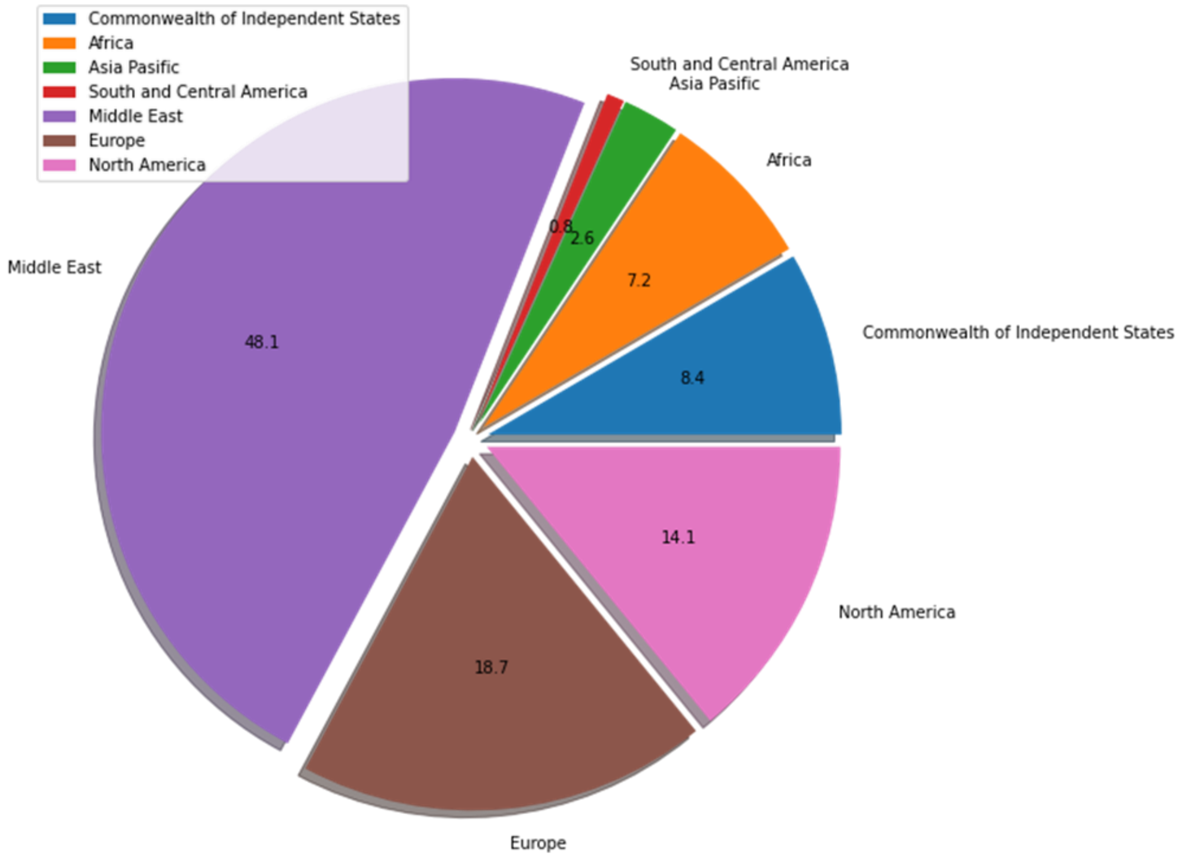


Fig. 1. The global distribution of proven oil reserves as of the end of 2019

Internal combustion engines that run on gasoline or diesel fuel emit a lot of harmful substances into the exhaust gas, which is a major source of pollution in our environment and a serious threat to human health. The transportation industry's usage of petroleum fuels adds to air pollution because it produces particles and generates abnormal climatic changes caused by carbon dioxide and major air pollutant emissions. One of the major problems the world is currently experiencing is the abundance of mineral-filled vehicles that can transport materials that damage the ozone layer[2].

The study into electric vehicles has received a lot of interest due to the depletion of oil reserves and environmental degradation [3, 4]. The adoption rates of electric vehicles (EVs) have been increasing globally due to several benefits, such as reduced noise, high efficiency, independence from fossil fuels, and zero pollution [5, 6]. “Fig.2”, shows global light vehicle production will shift to EV.

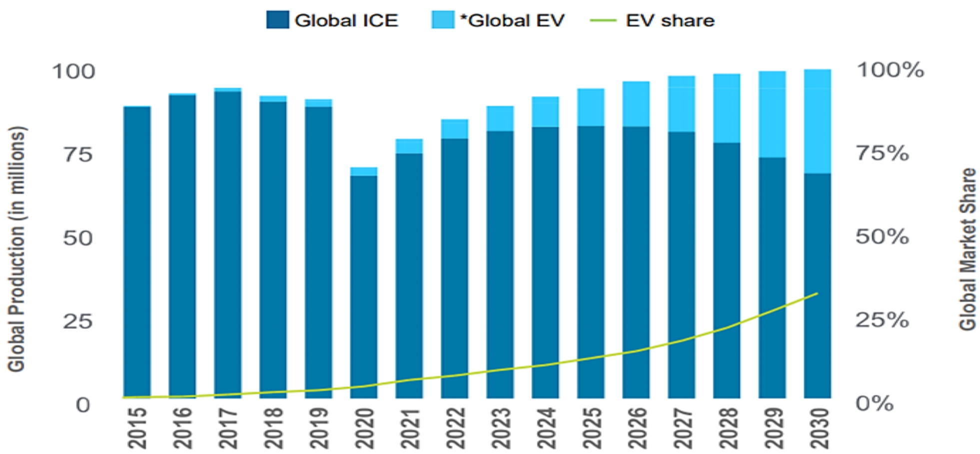


Fig. 2. Global Light Vehicle Production will Shift to EV

Global motor vehicle manufacturing fell sharply in 2020, dropping 15.4% from the year before, as a result of travel restrictions and a general slowdown in economic activity brought on by the COVID-19 pandemic. With production declines of 16.9% and 11.6%, respectively, passenger automobiles had a greater decline than commercial vehicles [7]. Production of motor vehicles worldwide is shown in "Fig.3" by type.

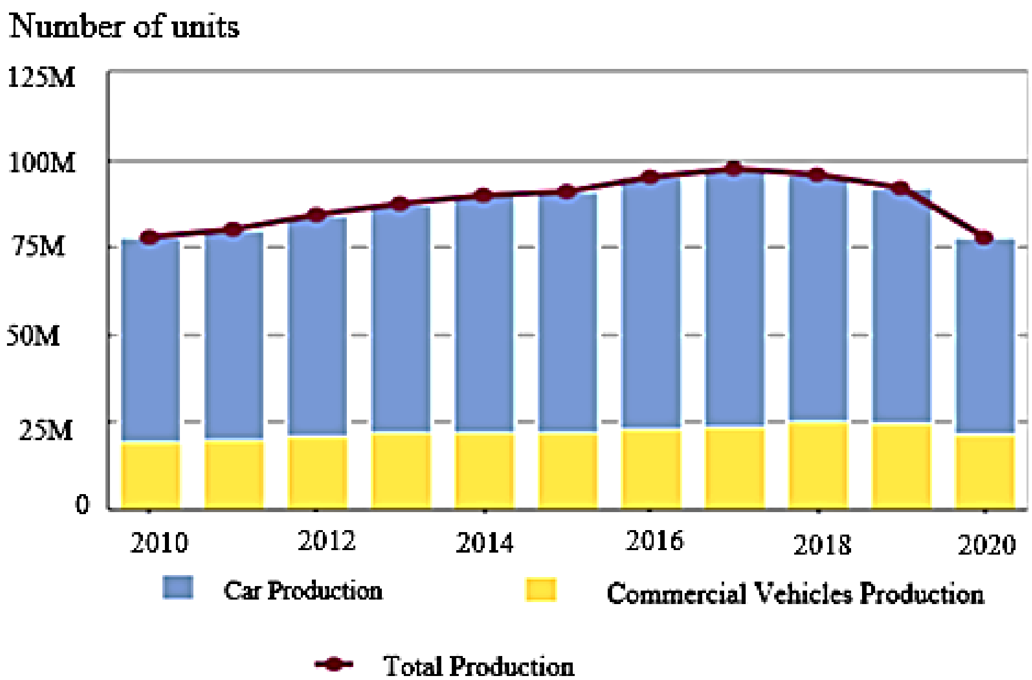


Fig. 3. Global Motor Vehicle Production

The exact number of vehicles worldwide is difficult to ascertain because several organizations are in charge of counting them; nonetheless, the most accurate estimate places the 2016 total at 1.32 billion automobiles, trucks, and buses. In the United States, Wards Auto came to that conclusion, however, it did not include heavy machinery or off-road vehicles. (Wards Intelligence is the source.)

In a few years afterward, according to some industry observers, the number of vehicles has already topped 1.4 billion. And it keeps expanding at a startling rate. To put that growth into perspective, there were only 342 million cars on the road in 1976, compared to around 670 million cars on the road in 1996. In 2036, there will be about 2.8 billion vehicles on the earth, assuming that the startling rate of expansion, which sees the total doubling every 20 years, continues.

2. VEHICLE EMISSIONS AND THEIR IMPACT

The environment, public health, and climate change are all significantly impacted by car emissions. Pollutants including nitrogen oxides, particulate matter, volatile organic compounds, and greenhouse gases are known to cause serious health concerns and drastically worsen air quality. This is especially true for people who live in densely populated urban areas.

The daily consumption of petroleum products is 60,000,000 barrels due to the presence of over a billion cars[8]. Air pollution is mostly caused by the transportation sector, in addition to the energy and heat-producing industries. In 2015, power and heat-generating industries accounted for 42% of worldwide CO2 emissions. According to "Fig. 4," whereas the transportation industry alone accounts for 24% of CO2 emissions. 75 percent of transportation-related emissions came from the road.[9, 10]. Fossil fuel use in transportation raises serious environmental concerns about air pollution and greenhouse gas (GHG) emissions [11, 12]

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

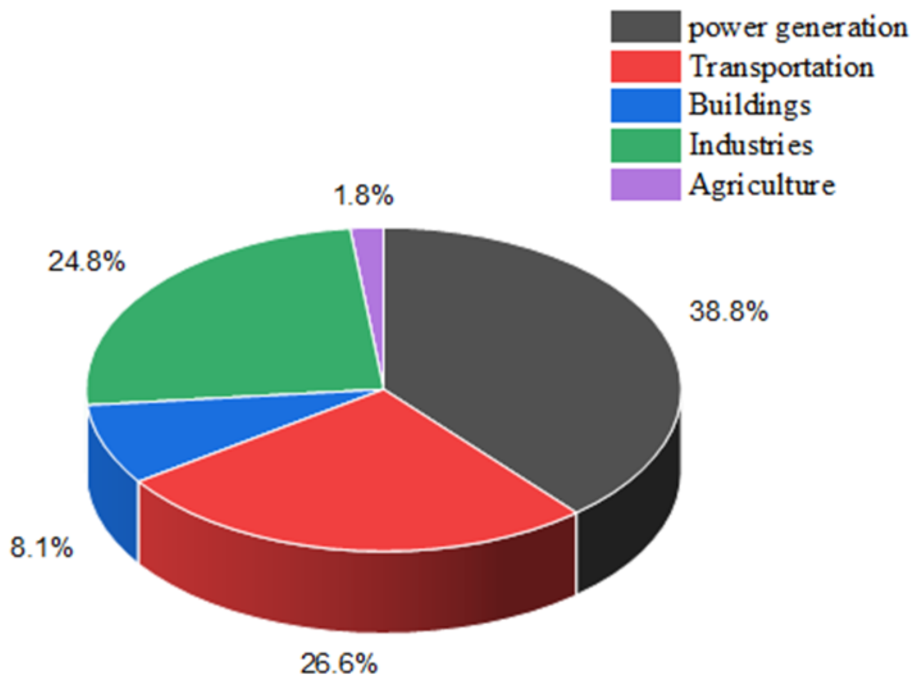


Fig. 4. Global CO2 emissions from fuel combustion by sector [13, 14]

Along with carbon dioxide (CO_2), automobiles powered by fossil fuels also release nitrogen oxides (NO_x), carbon monoxide (CO), sulphur oxides (SO_x), unburned hydrocarbons (C_xH_y), and hydro fluorocarbons (HFC) from leaking air conditioners. Despite having lower shares than CO_2, these gases can nevertheless have a large influence due to their greater Global Warming Potential (GWP) than CO_2. A gas's capacity to cause global warming is determined by how it performs in comparison to an equal volume of CO2. The major sources of glasshouse gases are presented in table 1 along with their percentage contribution to emission [12].

There is an urgent need to encourage more sustainable growth in the transportation sector because it is one of the main sources of pollution. Technological developments targeted at reducing the negative environmental effects of car emissions, with an emphasis on the creation and uptake of electric vehicles as a sustainable substitute. Particularly in heavily polluted metropolitan areas, electric cars provide a variety of significant environmental advantages [15].

It is appropriate to look at the entire energy supply chain to equate emissions from traditional vehicles to electric vehicles. This includes well-to-tank (WTT) emissions from energy production and supply (such as fossil fuel, electricity, or hydrogen) and tank-to-wheel (TTW) emissions from fuel usage in the vehicle, as shown in “Fig.5”.

Table 1. Major sources of glasshouse gases and their percentage contribution to emissions

sources of glasshouse gases	Glasshouse gas types	% emission
Fossil fuel combustion, deforestation	Carbon dioxide (CO2)	76
Biomass combustion, agricultural wastes	Methane (CH4)	13
Fertilizer use	Nitrous oxide (N2O)	3
Combustion of coal, oil, and diesel	Sulfur dioxide (SO2)	7
Refrigeration	Fluorinated gases (CFCs, HCFs)	1

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

Furthermore; well-to-tank (WTT) emissions are significantly impacted by the energy mix used for power generation and hydrogen production. However, the energy mix used for electricity generation varies greatly by region, as do the environmental benefits of EV usage. Besides this, the energy mix for power generation and hydrogen production has a substantial effect on WTT and, ultimately, overall WTW emissions[16, 17]. However, the energy mix used for power generation, as well as the environmental advantages of using electric vehicles, vary greatly from country to country. "Fig.7", illustrates the global distribution of the major energy sources used to generate electricity.

One of the factors that influence total emissions is energy efficiency. Despite the fact that the performance of various types of vehicles varies greatly, BEVs and FCVs are substantially more efficient than traditional ICE vehicles. ICE vehicles have a 20% efficiency ranking, whereas FCVs and BEVs have ratings of 50% and 70%, respectively. The average energy consumption of internal combustion engines and battery-electric passenger automobiles worldwide is shown in "Fig. 6". Using 7-liter fuel we can get 230 MJ whereas from an 18KWh battery 65 MJ energy.

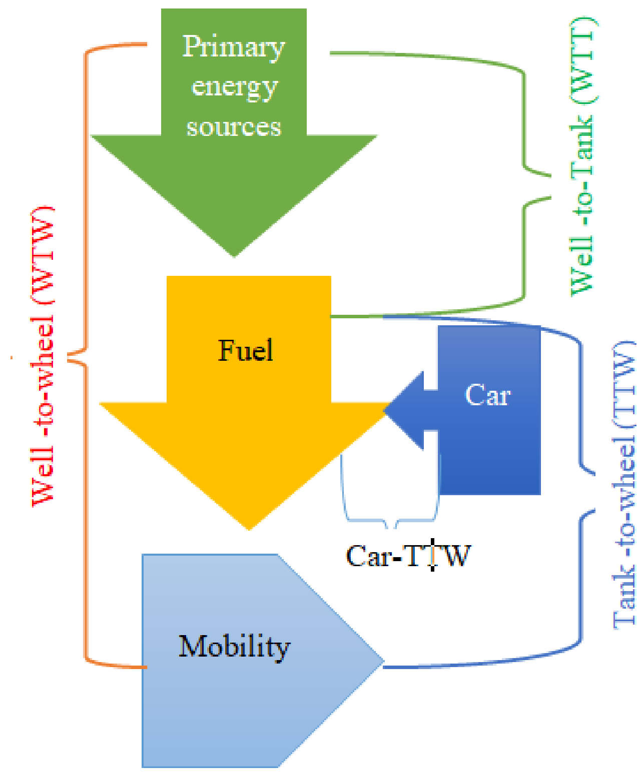


Fig.5. Emissions measurement technique[18].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

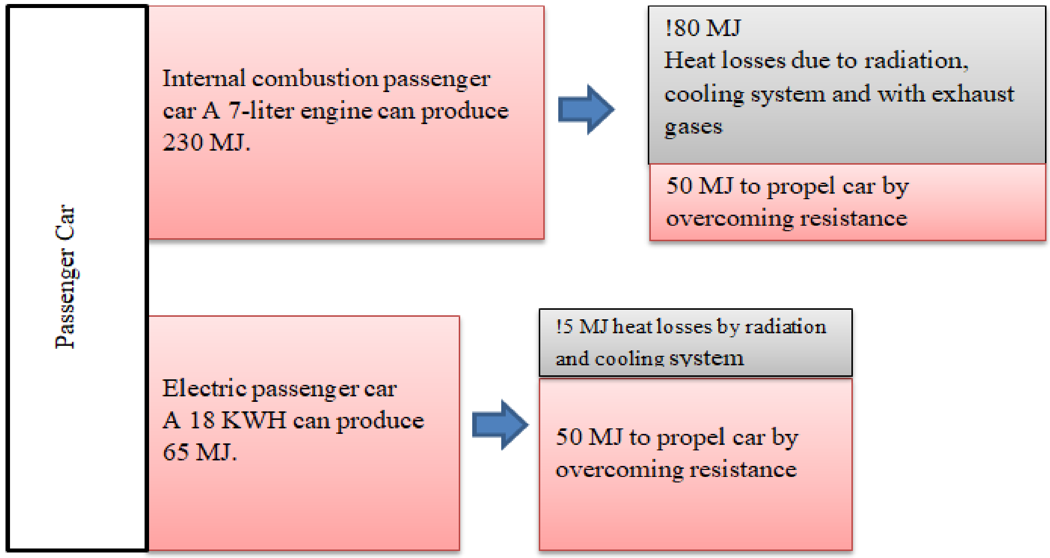
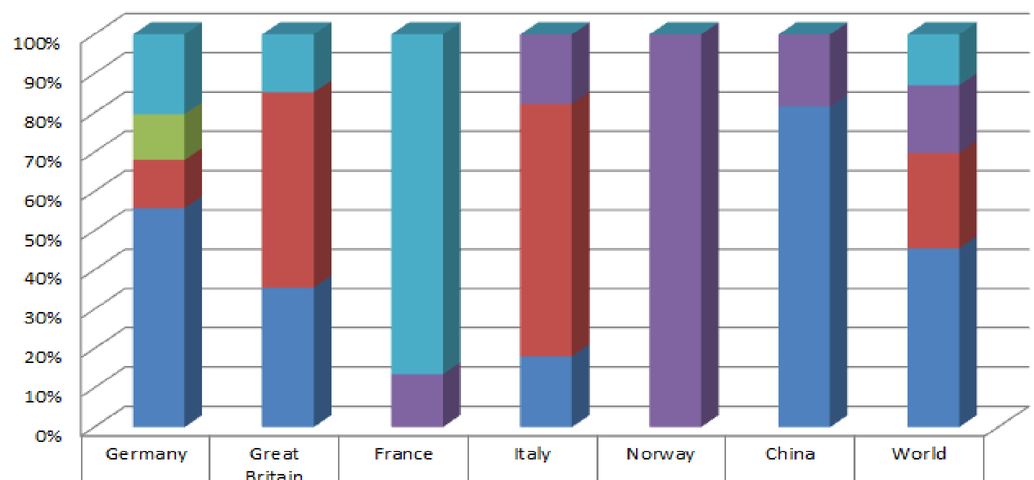


Figure 6: Tank/grid-to-wheel estimations for average worldwide energy consumption of internal combustion engines and battery electric passenger automobiles for a 100-kilometer drive[19-21]

The ultimate purpose of using alternative fuels is to reduce energy consumption in the transportation sector, especially the use of fossil fuels and the associated emissions. By boosting the share of renewable energy sources like wind, solar power, and hydropower in the power supply system, the detrimental environmental consequences of electric vehicles may be efficiently reduced [22].

Electric cars are only environmentally friendly while they are in service. Electric vehicles (EVs) can reduce vehicular emissions more efficiently if they are powered by renewable energy, avoiding pollution caused by fossil-fuel-powered generating stations. Therefore, raising the proportion of renewable energy in road transportation is an urgent need for action. "Fig. 8" displays efforts to enhance the use of renewable energy in road transportation.

One form of alternative energy is the hydrogen economy. If it is made using water electrolysis and electricity produced from tidal, wind, solar, or bioenergy, as seen in "Fig.9," then it can be considered a renewable source.



	Germany	Great Britain	France	Italy	Norway	China	World
Nuclear	15.9	13.5	76.5	0	0	0	11.7
Water	0	0	11.9	14.8	98.5	17.6	15.6
Wind	9.1	0	0	0	0	0	0
Natural gas	9.6	45.4	0	54.1	0	0	21.9
coal	43.6	32.5	0	15.2	0	78	41.2

Fig.7. Global share of major energy sources for electricity production[23]

As one of the major polluters, the transportation industry needs all the support it can get to expand more sustainably without harming the environment. Particularly in highly polluted metropolitan areas, electric cars provide some notable environmental benefits.

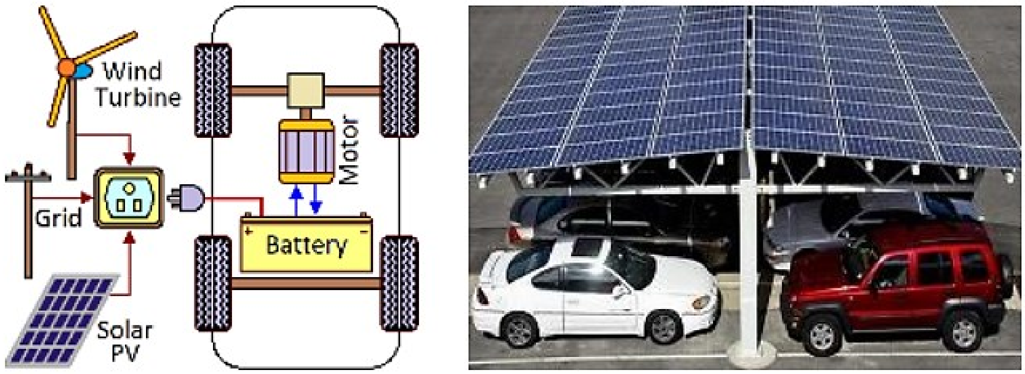


Fig.8. Initiatives to raise the proportion of renewable energy in road transport[24, 25].

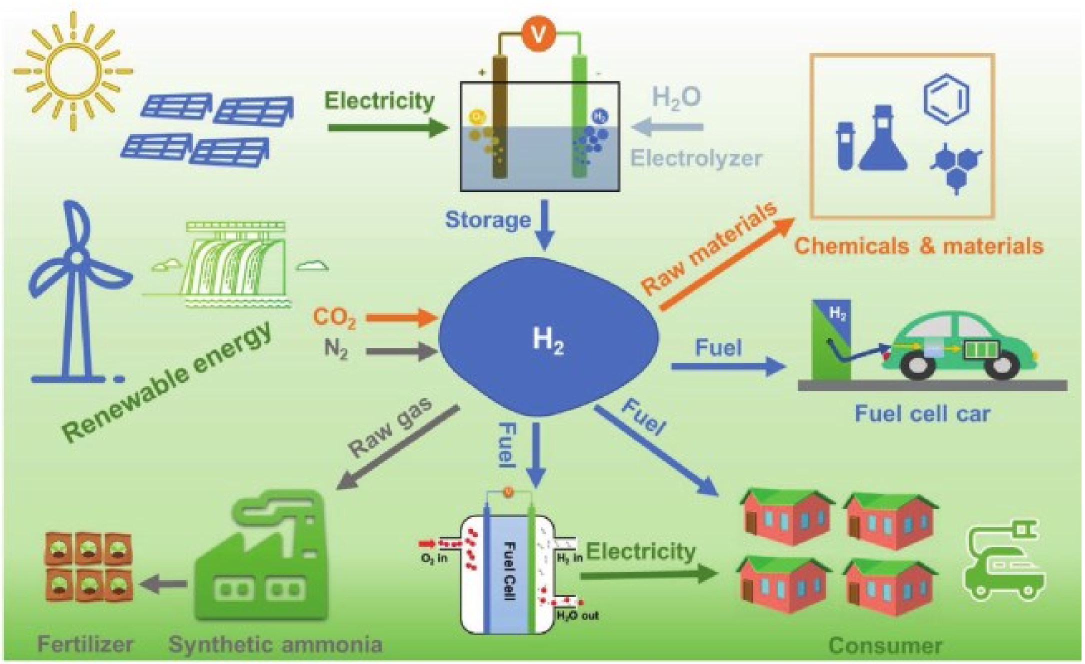


Fig 9. Renewable energies, hydrogen economy, and fuel cells [26].

Electric vehicles (EVs) get most of their power from the electric grid, so integrating highly energy-converted renewable energy sources into these grids simultaneously with the generation of low-carbon electricity will undoubtedly result in a cleaner environment for the energy and mobility sectors. Additionally, electric cars sometimes have a higher overall economy when compared to conventional fuel counterparts with internal combustion engines (ICEs). This has happened as a result of more efficient grid energy generation and regenerative braking.

since intermittent renewable energy sources like solar and wind energy cannot be used in situations where a consistent and stable supply is needed[27]. To address this challenge, lead acid, nickel metal hydride, and lithium-ion batteries have been used in EV energy storage systems.

To reduce the impact of automobile emissions by advancing technology to support greener transportation choices, such as electric cars. Comprehensive methods that incorporate supportive policy, public awareness, and technical innovation are necessary to effectively address the difficulties posed by automobile emissions.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

3. ELECTRIC VEHICLE DEVELOPMENT

Since the transportation industry contributes significantly to air pollution and carbon emissions worldwide, a move towards greener, more sustainable options is required. The development of electric vehicles has shown promise in addressing these issues.

3.1Battery Electric Vehicles

Energy stored in batteries powers the electric motors in battery electric vehicles (BEVs). Beyond just producing no exhaust emissions, BEVs also offer reduced running costs and better performance when compared to traditional gasoline-powered vehicles. The high cost, limited range, and lengthy charging times of BEVs are some of their drawbacks.

Electric cars have a long history dating back to before the invention of fossil fuel vehicles. EVs have existed for over a century as an emergent technology of the post-industrial revolution [28]. In the year 1839, Robert Anderson, a Scottish merchant, invented the world the first electric car. He designed, built, and tested a battery-powered horseless carriage. The first electric horseless vehicle can be seen in “Fig. 10” A significant development in electric propulsion was the battery-powered carriage. Additionally, "Fig.12" illustrates the advancement of electric vehicles.

Fig.10. The first electric horseless carriage [24, 29]

Fig.11. Illustration of "La Jamais Contente," the first car to reach 100 kilometers per hour in 1899[29, 30]

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

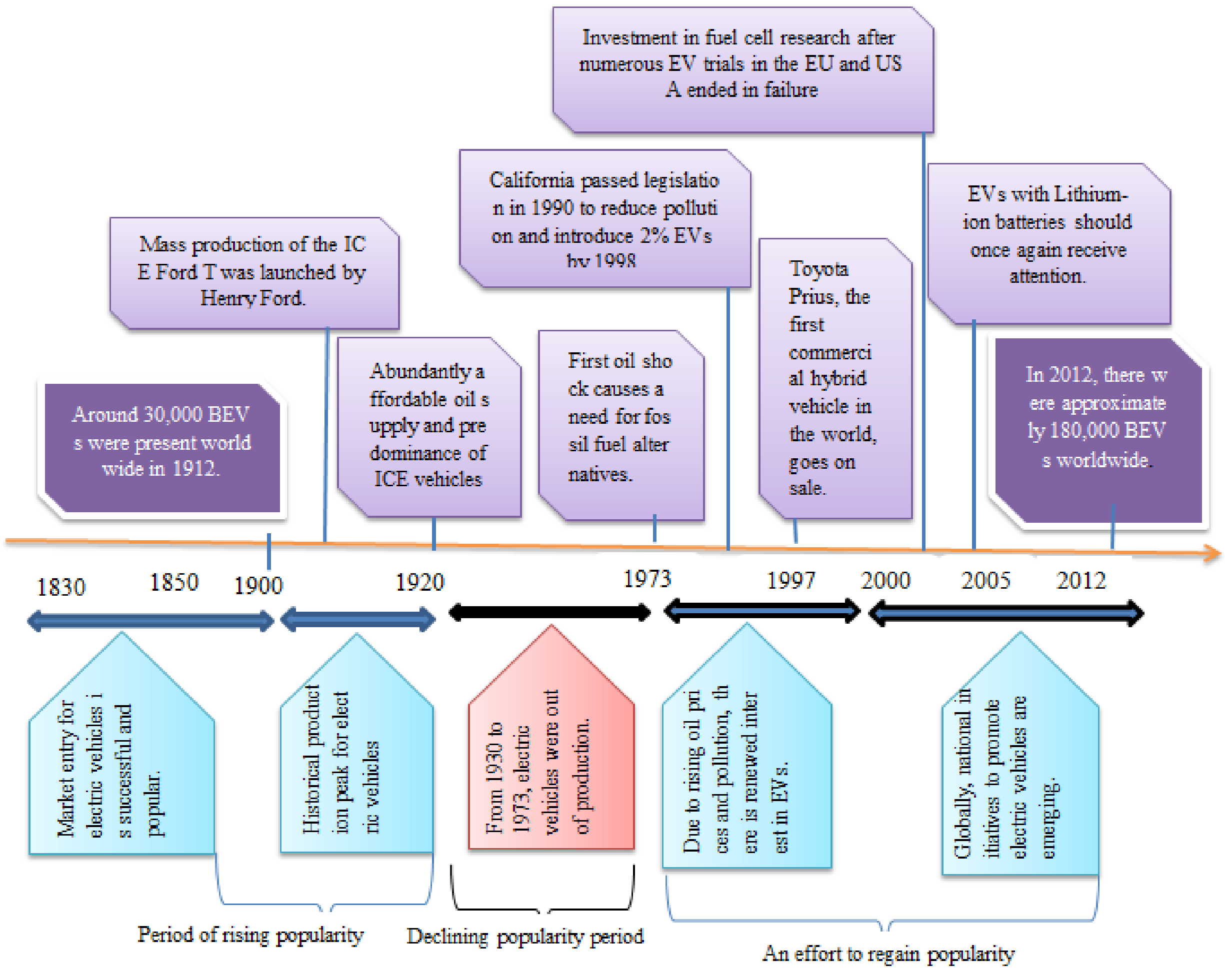


Fig.12. Significant events in the history of electric vehicles[31]

Vehicles powered by steam or gasoline, which were developed in 1867 by the German engineer Nicolaus August Otto, became less common after the Frenchmen Gaston Plant and Camille Faure discovered the first rechargeable energy accumulators in 1865 and 1881, respectively. As a result, these vehicles gained a lot of popularity beginning in 1880. There was a significant disparity between the number of gasoline and electric automobile owners [24].

Regenerative braking, which was developed by Frenchman M.A. Darracq on his 1897 coupe, was the most significant technological development of the century. It allows the vehicle's kinetic energy to be recovered when braking and recharging the batteries, significantly increasing the driving range [32, 33]. Electric taxis were first introduced in New York in 1896 by the Electric Vehicle Co.

Figure 11 shows Renowned pilot Camille Jenatzy broke the speed record in France in 1899 with his bullet-shaped electric convertible, "La Jamais Contente," achieving 100 km/h [29]. Following that, in 1907, the Detroit Electric Car Company started manufacturing rechargeable lead-acid battery-powered electric vehicles. Interestingly, Henry Ford and Thomas Edison both contributed to the project because they thought electric cars would have a bright future. In 1911, Edison's nickel-iron batteries were added to the growing fleet of in-demand vehicles.

But around 1915, the electric car's downfall was brought about by the following reason: With the introduction of the assembly line starting with the Ford Model T, the First World War, the advent of cheap oil, the creation of the first starter motor, the building of highways, and the incapacity to compete on price, the value of the driving range rose [29, 34].

Since EVs' propulsion mechanism is powered by traction batteries, the EV sector is significantly impacted by the technological advancement of these batteries. [35].Batteries for lighting, ignition, and starting are not the same as EV batteries, which must provide continuous power. High specific power, high specific energy, and high energy density are therefore crucial, as is having a larger energy capacity [36, 37]. Today's most popular rechargeable battery types for usage in electric vehicles (EVs) are lithium-ion, nickel-metal hydride, and lead-acid [38].

Battery capacity is not the only issue with Battery Electric Vehicles charging presents a hurdle. Battery and charging technology advancements are complementary. For electric vehicles drivers, charging technology is essential in reducing "range anxiety," and it is also vital to the BEV industry. Batteries for electric vehicles (EVs) can be charged via conductive, inductive, or battery swapping techniques, depending on the energy transfer mechanism [39]. Electric and hybrid vehicles were phased out until the 1970s. The Arab oil embargo caused a surge in gasoline prices, sparking renewed interest in electric vehicles [40, 41]. Electric vehicles have shorter driving ranges than vehicles with engines due to their reduced energy storage capacity

Battery electric vehicles (BEVs) hold great promise in mitigating air pollution and greenhouse gas emissions. But there are a lot of obstacles in the way of BEVs becoming widely used. By offering incentives for BEV purchases, making investments in the infrastructure needed for charging, and educating consumers about the advantages of BEVs, policymakers and industry stakeholders can significantly contribute to the acceleration of the adoption of BEVs.

3.2 Hybrid electric vehicles

In 1899, the Pieper Company in Liege, Belgium claimed to have created the first hybrid vehicle. To operate a hybrid vehicle, two or more distinct power sources must be used. HEV is formed by combining an ICE with one or more electric motors [30, 42-44]. Plug-in hybrid cars and non-plug-in hybrid cars are the two types of hybrid automobiles. Non-plug-in hybrids refuel their batteries using their ICE; plug-in hybrids can refuel their batteries by plugging them into an electrical outlet[45].

An electric motor, battery, and internal combustion engine are all combined in a hybrid electric vehicle, or HEV. By using the combustion engine for high-speed driving and the electric motor for low-speed travel, these vehicles are made to use less fuel and emit fewer emissions. HEVs are becoming more and more well-liked as a greener substitute for conventional gasoline-powered automobiles. Their lower emissions and enhanced fuel efficiency make them a desirable choice for those trying to lessen their carbon footprint.

Hybrid Electric Vehicles (HEVs) are available in a variety of configurations, each with special benefits and features. Series, parallel, series-parallel, and complex hybrid systems are the four primary categories of hybrid systems.in terms of how ICE and electric motors are related to the battery. “Fig, 13, 14, 15, and 16” depict the various hybrid drivetrains [46-49].

In a series hybrid configuration, the internal combustion engine (ICE) is only utilized to generate electricity; an electric motor drives the wheels. It is not the ICE that drives the wheels directly. This setup allows the ICE more flexibility in terms of size and operating range because it can be adjusted for its primary function of producing electricity with the aid of a charger. The electricity is then stored in the battery and supplied to the electric motor by the controllers, which drives the wheels [50, 51]. When the engine is turned off, the Series HEV can operate independently on the motor [52]. This type of hybrid vehicle performs best at low speeds, when the electric motor can provide all the power needed to propel the vehicle. The car is less effective than a parallel hybrid because it has more parts organized in a series configuration, which results in higher energy losses.

The electric motor and the ICE in a parallel hybrid system are mechanically attached to the wheels and can cooperate to move the car forward. The electric motor, ICE, generator, battery, power converter, and transmission make up the parallel hybrid electric vehicle powertrain. The ICE and electric motor system are placed in parallel in the Parallel HEV, combining their power to drive the wheels. Furthermore, this arrangement is more energy-efficient than the HEV series. By helping the internal combustion engine (ICE) produce greater power, the electric motor can also provide instantaneous power when high performance is required. To connect and provide combined power, however, a sophisticated linkage between the engine and motor shaft is needed.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

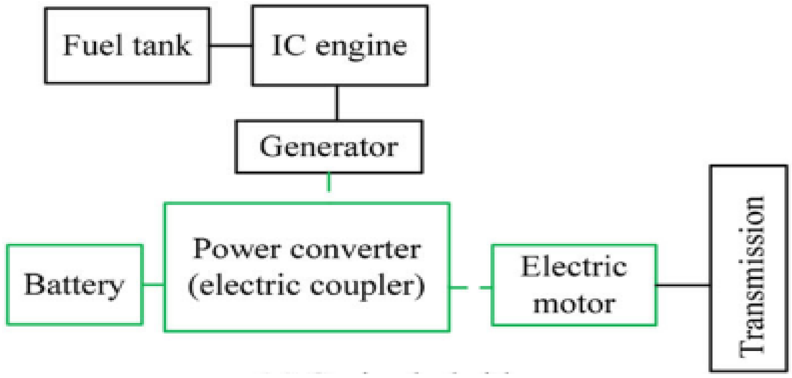


Fig.13. shows the layout of a series' drive train.

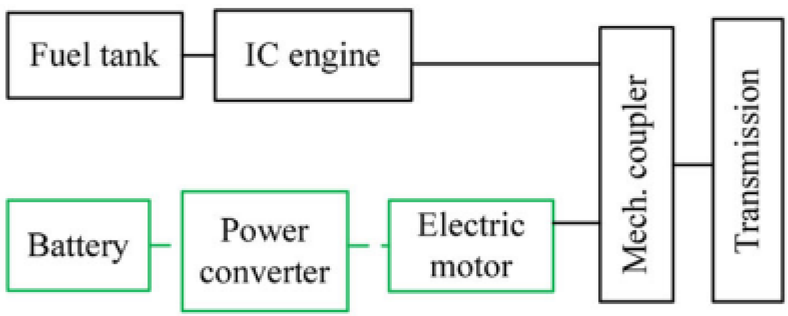


Fig.14. shows the layout of the Parallel drive train.

A hybrid system that combines aspects of series and parallel architectures is called series-parallel. The engine generates the power for the Power Split HEV powertrain, which is then split into two paths. One path connects directly to the transmission and powers the wheels like a regular car, while the other path connects to the generator, which generates electricity and stores it in the battery to power the motor, which is connected directly to the driving shaft after the transmission [53, 54]. Therefore, in this case, controlling power distribution to the wheels is possible with more efficiency and flexibility thanks to the concepts of series and parallel. Depending on the driving situation and required power, the car can run in electric-only mode, ICE-only mode, or a combination of both.

Many technologies are used by complex hybrid cars to increase performance and efficiency. These technologies could be variable-displacement engines, active aerodynamics, and regenerative brakes. Given that both the generator and the electric motor are electric devices, the complicated hybrid and the series-parallel hybrid are comparable. The power flow in an electric motor in a complex hybrid is bidirectional, while in a series-parallel hybrid, the power flow in the generator is unidirectional [55]. The most efficient kind of hybrid car is a complex one, but it needs advanced control and engineering techniques. Most costly as well.

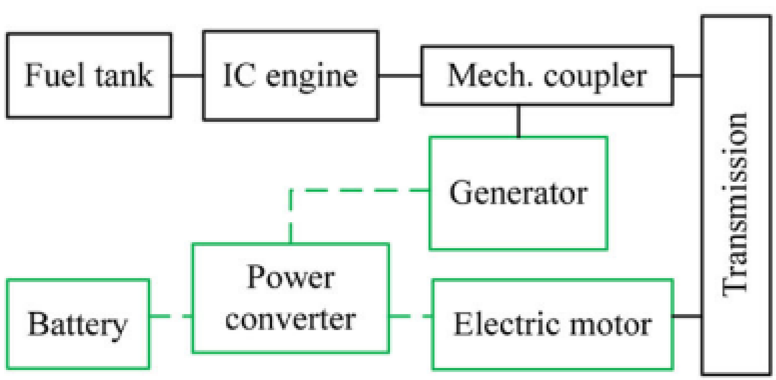


Fig.15 shows the layout of a Series-parallel drive train

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

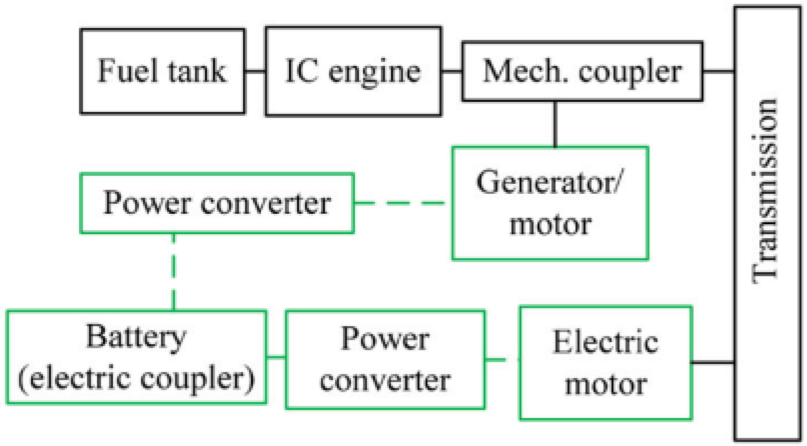


Fig.16. Complex hybrid system

The best kind of hybrid electric car for you will depend on your needs and driving style. If you drive through cities frequently, a series hybrid car can be an excellent fit for you. For those who drive a lot on the highway, a parallel hybrid car would be a better option. A sophisticated hybrid car can be your best bet if you're looking for the most efficient hybrid out there.

Hybrid Electric Vehicles (HEVs) can also be categorized according to their degree of electrification and other distinct qualities. In 1995, competing automakers showed increased interest in hybrid electric vehicles due to the possibility of lower emissions and fuel efficiency. Consequently, a number of hybrid electric vehicle technologies were produced such as micro HEVs, mild HEVs, full HEVs, and plug-in HEVs [56].

1. Micro HEVs:

The simplest kind of hybrid electric vehicle is the micro HEV. These are the most basic type of hybrid cars, commonly referred to as start-stop hybrids. They have an internal combustion engine (ICE) start-stop technology that stops the engine when the car stops and restarts it when the driver lets off of the brake pedal [57, 58]. In city driving situations, in particular, this helps save fuel and cut pollutants. While they use the start-stop mechanism to increase fuel efficiency, micro HEVs usually do not include an electric motor for propulsion.

2. Mild HEVs:

A small electric motor helps the internal combustion engine (ICE) during acceleration and other driving conditions in mild hybrid electric vehicles (HEVs). A larger integrated alternator/starter motor and a battery that enables power assistance during vehicle propulsion distinguish the mild HEV from the tiny HEV. Comparing mild hybrid vehicles to non-hybrid vehicles, mild HEVs typically result in a 20–25% increase in fuel efficiency [57-59]. Additionally, regenerative braking is a characteristic of mild HEVs that stores energy when braking in a small battery for later use. They depend mostly on the ICE for propulsion, though, as they are typically unable to run entirely on electricity..

3. Full HEVs:

Full HEVs, or powerful hybrids, have a larger electric motor and Full HEVs have far larger batteries and electric motors than micro or mild HEVs. They can function in electric-only mode at low speeds and short distances, with the electric motor assisting the ICE during acceleration [60]. Compared to micro and mild HEVs, full HEVs have substantially smaller engines and need more advanced energy management systems. Full HEVs can smoothly transition between electric and internal combustion engine power depending on the driving situation. They also have regenerative braking.

4. PLUG-IN HEVS (PHEVS):

The fundamental design of PHEVs is the same as that of full HEVs; however, PHEVs have the option of an extended all-electric driving range because they can be charged externally. Plug-In Hybrid Electric Vehicles (PHEVs) are able to go farther on electricity alone because they feature a smaller engine and greater electrical components, such as an electric motor and battery [46, 61]. PHEVs function like full hybrids, employing the internal combustion engine for propulsion when the battery runs low. PHEVs provide the range of a traditional hybrid vehicle for longer trips, but they also give drivers the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

flexibility of driving entirely on electricity for shorter ones. "Fig.17" compares and classes different features of hybrid electric vehicles.

Hybrid electric vehicle models are designed to meet diverse driving needs and preferences by providing varying degrees of electrification, fuel efficiency, and environmental benefits. The next generation of hybrid cars will be considerably more efficient and have a less environmental effect as technology develops.

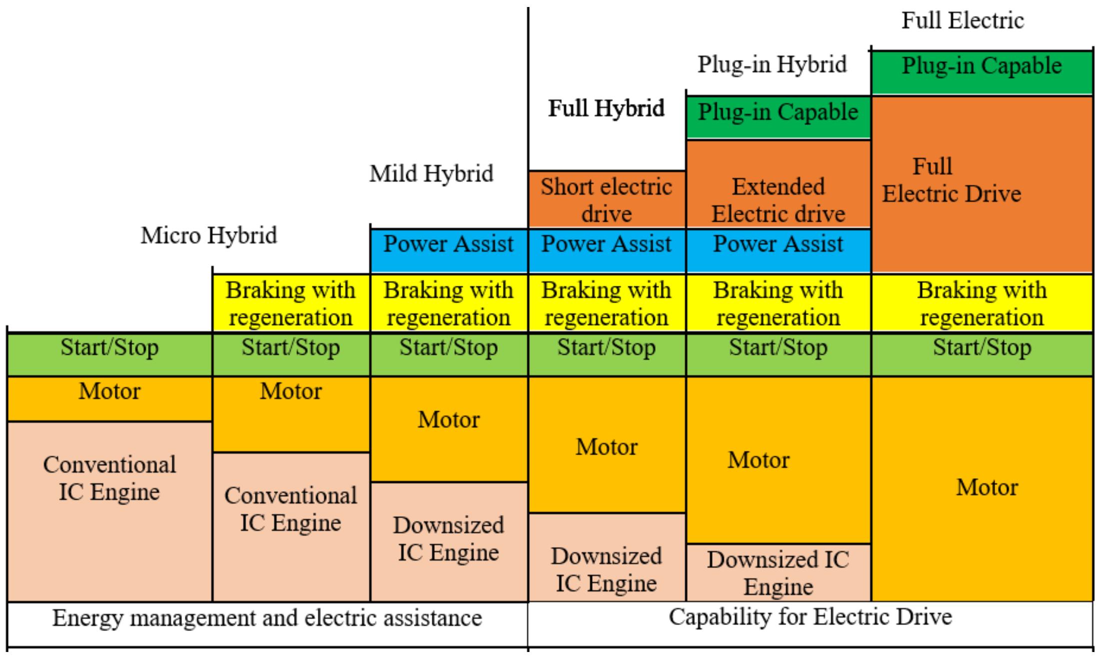


Fig.17. Classification and features of Hybrid EVs

Toyota's technological roadmap for hybrid vehicles is a detailed strategy outlining the company's objectives for creating and releasing hybrid cars. Toyota is continuously striving to meet fuel economy goals, lower emissions, and contribute to the development of a more sustainable future through the performance and efficiency of its hybrid cars. Fig. 18 shows the Toyota Company's anticipated Road Map for Hybrid Technology. Its objective is to increase the use of electric vehicles while creating the greenest cars possible.

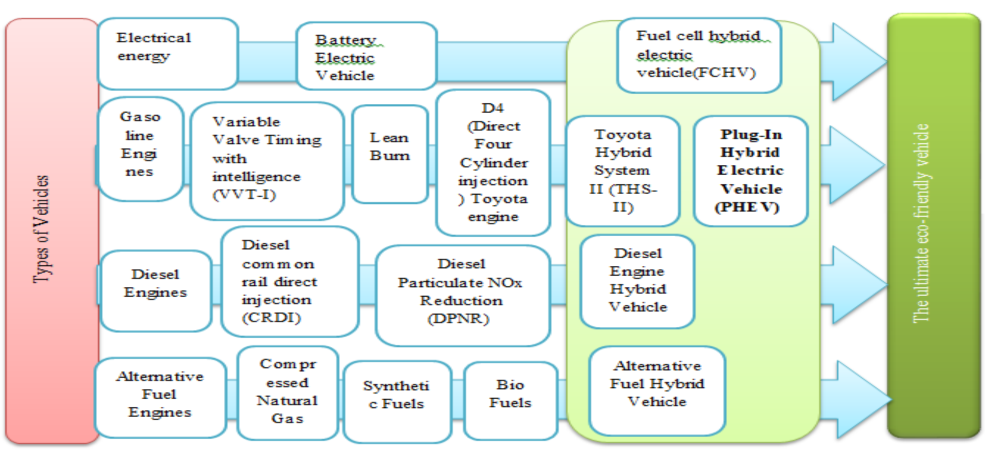


Fig.18. Hybrid technological roadmap (Courtesy of Toyota) [62]. 3.3 Fuel Cell Vehicles

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 13 Issue 08, August-2024

A lengthy history has been written about the advancement of fuel cell technology and hydrogen production. The following significant turning points in their past development are listed: Early in the 19th century, the idea of using hydrogen as fuel was proposed. Hydrogen gas has been the subject of experiments by scientists and engineers for a variety of purposes, including possible fuel.

Sir William Rober Grove in Wales invented the first fuel cell in 1838, entitled the "Grove Gas Battery." Francis Bacon produced a 5 kW fuel cell in 1959. However, it was in the 1960s that general electricity made significant progress with the proton exchange membrane fuel cell (PEM).

As both the United States and the Soviet Union utilized fuel cells to power their spacecraft during the space race in the 1960s, fuel cells became well-known. NASA produced drinking water and energy for the astronauts on the Gemini and Apollo flights using fuel cells. When General Motors developed a six-passenger Electro van in 1967, it was only permitted on company property for safety concerns. Several automakers started creating fuel cell vehicles for commercial use in the late 1990s and early 2000s. The Toyota Mirai, the first fuel cell car built in large quantities, debuted in 2014.

Numerous techniques for producing hydrogen have been developed over time, including the electrolysis of water, steam methane reforming, and other renewable techniques including solar and wind-powered electrolysis. Hydrogen can be considered as a renewable resource if it is created through the electrolysis of water using power produced by solar, tidal, wind, and bioenergy [63, 64]. Hydrogen is attractive due to the fact that it produces water as a byproduct when it burns or reacts with air in a fuel cell to generate electricity.

Electricity is produced by a chemical process in a fuel cell using hydrogen gas, and an electric motor is used to drive the vehicle in fuel cell vehicles (FCVs). Because only heat and water vapour are produced during the chemical reaction, these cars have zero tailpipe emissions. Fuel cell vehicles (FCVs) present a viable substitute for conventional internal combustion engine vehicles due to their capacity for extended driving ranges and quick refueling time.

Even though two major energy-related problems that the world is currently facing can be resolved by hydrogen and fuel cell technologies: completely eliminating reliance on fossil fuels and drastically cutting CO_2 (carbon dioxide) emissions. Achieving a hydrogen economy is not without significant challenges, though. These include the development of new synthetic fuels, fuel cell technology, and efficient methods for converting renewable energy sources such as solar, wind, tidal, or bioenergy into electricity. They also include the efficient electrolysis of water to produce hydrogen and oxygen [11]. "Fig.19", illustrates the major achievements and stages in the development of hydrogen and fuel cell vehicles.

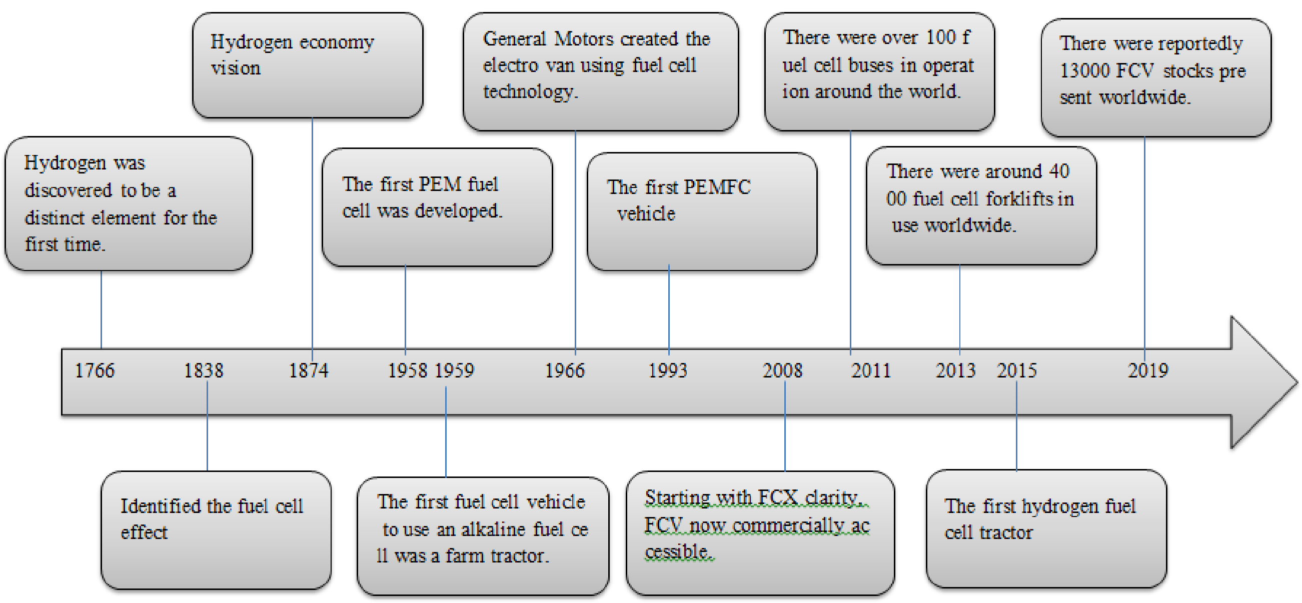


Fig.19 Historical developments in the production of hydrogen and fuel cell vehicles[65].

With continuous efforts to further advance these technologies for widespread adoption and commercial viability, these historical developments have set the foundation for the current level of hydrogen production and fuel cell cars.

4. CONCLUSION

One of the major industries that continues to contribute significantly to global emissions is the automotive sector. This growing issue is mostly caused by an over-reliance on fossil fuels as the primary energy source. These issues have been solved using a variety of strategies. Using electric cars, utilizing more eco-friendly alternative fuels, and designing better engines are a few of them. The development of electric vehicles was also critically examined. Electric vehicles are generally thought of as a replacement for internal combustion engines.

Electric vehicles (EVs) can reduce vehicular emissions more effectively if they are powered by electricity generated by renewable energy, avoiding pollution caused by generating stations that use fossil fuels. If not electric vehicles are only clean while they are in operation. As a result, renewable energy's position in the transportation sector is critical.

Prior research indicates that the swift advancement of electric vehicles is presenting a viable substitute as an efficient and eco-friendly means of transportation, particularly in urban areas. However, further investigation is necessary regarding the following issue.

1. Battery Electric vehicle

✓ The battery and its management
✓ Infrastructure for charging
✓ The cost of a battery-electric car

2. Hybrid Electric vehicle

✓ Management, optimization, and control over various energy sources
✓ Sizing and administration of batteries

3. Fuel Cell EVs

✓ Price, cycle life, and reliability of fuel cells
✓ Infrastructure for the use of hydrogen
✓ The cost of producing hydrogen

REFERENCE

[1] T. H. Gebrekidan, "Characterization of Biodiesel Prepared from Cactus fruit Seed Oil as Alternative Fuel for Diesel Engine," 2020.
[2] Y. Zou, J. Zhao, X. Gao, Y. Chen, and A. J. J. o. C. P. Tohidi, "Experimental results of electric vehicles effects on low voltage grids," vol. 255, p. 120270, 2020.
[3] S. S. Ravi and M. J. E. Aziz, "Utilization of electric vehicles for vehicle-to-grid services: Progress and perspectives," vol. 15, no. 2, p. 589, 2022.
[4] K. Vincent et al., "Alternative Fuels and Advanced Vehicle Technologies for Improved Environmental Performance: Towards Zero Carbon Transportation," in Alternative Fuels and Advanced Vehicle Technologies for Improved Environmental Performance (Second Edition): Towards Zero Carbon Transportation: Woodhead Publishing, 2022, pp. 711-741.
[5] M. Hossain, L. Kumar, M. El Haj Assad, and R. J. C. Alayi, "Advancements and future prospects of electric vehicle technologies: a comprehensive review," vol. 2022, 2022.
[6] J. Du and D. J. A. E. Ouyang, "Progress of Chinese electric vehicles industrialization in 2015: A review," vol. 188, pp. 529-546, 2017.
[7] F. J. S. C. Hoeft, "The case of sales in the automotive industry during the COVID-19 pandemic," vol. 30, no. 2, pp. 117-125, 2021.
[8] Ö. Balcı et al., "Numerical and experimental investigation of fuel consumption and CO2 emission performance for a parallel hybrid vehicle," Alexandria Engineering Journal, vol. 60, no. 4, pp. 3649-3667, 2021.
[9] T. A. Skouras, P. K. Gkonis, C. N. Ilias, P. T. Trakadas, E. G. Tsampasis, and T. V. J. C. T. Zahariadis, "Electrical vehicles: Current state of the art, future challenges, and perspectives," vol. 2, no. 1, pp. 1-16, 2019.
[10] Z. Xia, D. Wu, and L. J. S. Zhang, "Economic, functional, and social factors influencing electric vehicles' adoption: An empirical study based on the diffusion of innovation theory," vol. 14, no. 10, p. 6283, 2022.
[11] L. F. S. Prates et al., "Sustainability for All? The challenges of predicting and managing the potential risks of end-of-life electric vehicles and their batteries in the Global South," 2022.
[12] J. A. Sanguesa, V. Torres-Sanz, P. Garrido, F. J. Martinez, and J. M. J. S. C. Marquez-Barja, "A review on electric vehicles: Technologies and challenges," vol. 4, no. 1, pp. 372-404, 2021.
[13] C. Parag Jose, S. J. I. D. Meikandasivam, D. P. i. Aerospace, and F.-. Automotive Engineering: I-DAD, "A review on the trends and developments in hybrid electric vehicles," pp. 211-229, 2017.
[14] K. O. Yoro and M. O. Daramola, "CO2 emission sources, greenhouse gases, and the global warming effect," in Advances in carbon capture: Elsevier, 2020, pp. 3-28.
[15] A. Alsharif, C. W. Tan, R. Ayop, A. Dobi, K. Y. J. S. E. T. Lau, and Assessments, "A comprehensive review of energy management strategy in Vehicle-to-Grid technology integrated with renewable energy sources," vol. 47, p. 101439, 2021.
[16] B. Cox, C. Bauer, A. M. Beltran, D. P. van Vuuren, and C. L. J. A. E. Mutel, "Life cycle environmental and cost comparison of current and future passenger cars under different energy scenarios," vol. 269, p. 115021, 2020.
[17] R. Sacchi, C. Bauer, B. Cox, C. J. R. Mutel, and S. E. Reviews, "When, where and how can the electrification of passenger cars reduce greenhouse gas emissions?," vol. 162, p. 112475, 2022.
[18] A. Ajanovic and R. J. F. c. Haas, "Economic and environmental prospects for battery electric-and fuel cell vehicles: a review," vol. 19, no. 5, pp. 515-529, 2019.

[19] K. Holmberg and A. J. T. I. Erdemir, "The impact of tribology on energy use and CO2 emission globally and in combustion engine and electric cars," vol. 135, pp. 389-396, 2019.
[20] S. Chu and A. J. n. Majumdar, "Opportunities and challenges for a sustainable energy future," vol. 488, no. 7411, pp. 294-303, 2012.
[21] E. Roshandel, A. Mahmoudi, S. Kahourzade, A. Yazdani, and G. J. E. Shafiullah, "Losses in efficiency maps of electric vehicles: An overview," vol. 14, no. 22, p. 7805, 2021.
[22] M. Hossain, L. Kumar, M. Islam, and J. J. J. o. A. T. Selvaraj, "A comprehensive review on the integration of electric vehicles for sustainable development," vol. 2022, 2022.
[23] C. Stan, Alternative propulsion for automobiles. Springer, 2017.
[24] C. C. J. P. o. t. I. Chan, "The rise & fall of electric vehicles in 1828–1930: Lessons learned [scanning our past]," vol. 101, no. 1, pp. 206-212, 2012.
[25] K. J. E. S. Vidyanandan, "Overview of electric and hybrid vehicles," vol. 3, pp. 7-14, 2018.
[26] J. J. E. Wang, "Barriers of scaling-up fuel cells: Cost, durability and reliability," vol. 80, pp. 509-521, 2015.
[27] M. Z. Daud, A. Mohamed, M. J. E. C. Hannan, and Management, "An improved control method of battery energy storage system for hourly dispatch of photovoltaic power sources," vol. 73, pp. 256-270, 2013.
[28] M. Guarnieri, "Looking back to electric cars," in 2012 Third IEEE HISTory of ELectro-technology CONference (HISTELCON), 2012: IEEE, pp. 1-6.
[29] N. Burton, History of electric cars. Crowood, 2013.
[30] J. Larminie and J. Lowry, Electric vehicle technology explained. John Wiley & Sons, 2012.
[31] A. J. W. I. R. E. Ajanovic and Environment, "The future of electric vehicles: prospects and impediments," vol. 4, no. 6, pp. 521-536, 2015.
[32] M. Ehsani, Y. Gao, S. Longo, and K. M. Ebrahimi, Modern electric, hybrid electric, and fuel cell vehicles. CRC press, 2018.
[33] J. D. Graham, The Global Rise of the Modern Plug-In Electric Vehicle: Public Policy, Innovation and Strategy. Edward Elgar Publishing, 2021.
[34] C. Hadjilambrinos, "Reexamining the Automobile's Past: What Were the Critical Factors That Determined the Emergence of the Internal Combustion Engine as the Dominant Automotive Technology?," Bulletin of Science, Technology & Society, vol. 41, no. 2-3, pp. 58-71, 2021.
[35] M. A. Hannan, M. H. Lipu, A. Hussain, A. J. R. Mohamed, and S. E. Reviews, "A review of lithium-ion battery state of charge estimation and management system in electric vehicle applications: Challenges and recommendations," vol. 78, pp. 834-854, 2017.
[36] D. V. Pelegov and J. J. B. Pontes, "Main drivers of battery industry changes: Electric vehicles—A market overview," vol. 4, no. 4, p. 65, 2018.
[37] S. Alshahrani, M. Khalid, and M. J. I. A. Almuhaini, "Electric vehicles beyond energy storage and modern power networks: Challenges and applications," vol. 7, pp. 99031-99064, 2019.
[38] B. Nykvist and M. J. N. c. c. Nilsson, "Rapidly falling costs of battery packs for electric vehicles," vol. 5, no. 4, pp. 329-332, 2015.
[39] I. Rahman, P. M. Vasant, B. S. M. Singh, M. Abdullah-Al-Wadud, N. J. R. Adnan, and S. E. Reviews, "Review of recent trends in optimization techniques for plug-in hybrid, and electric vehicle charging infrastructures," vol. 58, pp. 1039-1047, 2016.
[40] H. Chan, "A new battery model for use with battery energy storage systems and electric vehicles power systems," in 2000 IEEE power engineering society winter meeting. conference proceedings (Cat. No. 00CH37077), 2000, vol. 1: IEEE, pp. 470-475.
[41] R. R. Heffner, K. S. Kurani, T. S. J. T. R. P. D. T. Turrentine, and Environment, "Symbolism in California's early market for hybrid electric vehicles," vol. 12, no. 6, pp. 396-413, 2007.
[42] G. P. Wang, Q. N. Wang, P. Y. Wang, Y. H. Zheng, and G. M. Lu, "Study on Power-Train Configuration of Hybrid Electric Vehicle Equipped with Dual Clutch Transmission," in Applied Mechanics and Materials, 2015, vol. 713: Trans Tech Publ, pp. 1465-1471.
[43] Y. Mae, Dynamics and Advanced Motion Control of Off-road UGVs. Academic Press, 2020.
[44] M. S. Jneid, P. Harth, and P. Ficzere, "In-wheel-motor electric vehicles and their associated drivetrains," International Journal for Traffic and Transport Engineering, vol. 10, no. 4, pp. 415-431, 2020.
[45] A. Isenstadt, Z. Yang, S. Searle, and J. German, "Real world usage of plug-in hybrid vehicles in the United States," ed: The International Council on Clean Transportation. https://theicct. org …, 2022.
[46] M. S. Jneid, P. Harth, and P. J. I. J. T. T. E. Ficzere, "In-wheel-motor electric vehicles AND their associated drivetrains," vol. 10, no. 4, pp. 415-431, 2020.
[47] W. Zhuang et al., "A survey of powertrain configuration studies on hybrid electric vehicles," vol. 262, p. 114553, 2020.
[48] G. Rizzo, S. Naghinajad, F. A. Tiano, and M. J. E. Marino, "A survey on through-the-road hybrid electric vehicles," vol. 9, no. 5, p. 879, 2020.
[49] K. V. Singh, H. O. Bansal, and D. J. J. o. M. T. Singh, "A comprehensive review on hybrid electric vehicles: architectures and components," vol. 27, pp. 77-107, 2019.
[50] A. Rezaei, J. Burl, A. Solouk, B. Zhou, M. Rezaei, and M. J. A. E. Shahbakhti, "Catch energy saving opportunity (CESO), an instantaneous optimal energy management strategy for series hybrid electric vehicles," vol. 208, pp. 655-665, 2017.
[51] M. F. M. Sabri, K. A. Danapalasingam, M. F. J. R. Rahmat, and S. E. Reviews, "A review on hybrid electric vehicles architecture and energy management strategies," vol. 53, pp. 1433-1442, 2016.
[52] C. Mi and M. A. Masrur, Hybrid electric vehicles: principles and applications with practical perspectives. John Wiley & Sons, 2017.
[53] O. M. J. I. J. o. E. Govardhan and Techniques, "Fundamentals and classification of hybrid electric vehicles," vol. 3, no. 5, pp. 194-198, 2017.
[54] V. T. Minh, A. Sivitski, M. Tamre, and I. J. N. a. o. e. d. Penkov, "Modeling and control strategy for hybrid electrical vehicle," pp. 27-57, 2015.
[55] G. Livinţ, V. Horga, M. Răţoi, M. J. E. V. M. Albu, and Simulations, "Control of hybrid electrical vehicles," pp. 41-66, 2011.
[56] J. Garche, C. Dyer, P. T. Moseley, Z. Ogumi, D. A. Rand, and B. Scrosati, Encyclopedia of electrochemical power sources. Newnes, 2013.
[57] D. S. Cardoso, P. O. Fael, and A. J. E. r. Espírito-Santo, "A review of micro and mild hybrid systems," vol. 6, pp. 385-390, 2020.
[58] S. Ou, D. Gohlke, and Z. J. E. Lin, "Quantifying the impacts of micro-and mild-hybrid vehicle technologies on fleetwide fuel economy and electrification," vol. 4, p. 100058, 2020.
[59] Y. Yin, Y. Ran, L. Zhang, X. Pan, Y. J. J. o. C. S. Luo, and Engineering, "An energy management strategy for a super-mild hybrid electric vehicle based on a known model of reinforcement learning," vol. 2019, 2019.
[60] C. Chellaswamy, R. J. R. Ramesh, and S. E. Reviews, "Future renewable energy option for recharging full electric vehicles," vol. 76, pp. 824-838, 2017.
[61] J. Zhao, X. Xi, Q. Na, S. Wang, S. N. Kadry, and P. M. J. E. I. A. R. Kumar, "The technological innovation of hybrid and plug-in electric vehicles for environment carbon pollution control," vol. 86, p. 106506, 2021.
[62] C. C. J. P. o. t. I. Chan, "The state of the art of electric, hybrid, and fuel cell vehicles," vol. 95, no. 4, pp. 704-718, 2007.
[63] M. Stygar and T. J. i. j. o. h. e. Brylewski, "Towards a hydrogen economy in Poland," vol. 38, no. 1, pp. 1-9, 2013.
[64] A. Züttel, A. Remhof, A. Borgschulte, O. J. P. T. o. t. R. S. A. M. Friedrichs, Physical, and E. Sciences, "Hydrogen: the future energy carrier," vol. 368, no. 1923, pp. 3329-3342, 2010.
[65] A. Ajanovic and R. J. I. j. o. h. e. Haas, "Prospects and impediments for hydrogen and fuel cell vehicles in the transport sector," vol. 46, no. 16, pp. 10049-10058, 2021.