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A Comprehensive Review on Types of Electric Vehicle and Their Impact on Sustainable Transportation

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ABSTRACT—

Electric vehicles (EVs) have gained significant attention as a sustainable solution to reduce greenhouse gas emissions and mitigate environmental challenges associated with traditional fossil fuel-powered vehicles. The many kinds of electric vehicles that are covered in this paper include Fuel Cell Electric Vehicles (FCEVs), Plug-in Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs), and Battery Electric Vehicles (BEVs). Every variety is thoroughly examined, encompassing their fundamental principles of operation, essential elements, benefits, constraints, and uses. The technical features of EVs, including battery technology, charging infrastructure, electric motors, and energy management systems, are examined in this paper. The economic and environmental effects of electric vehicles (EVs) are evaluated, highlighting their contribution to combating climate change and advancing sustainable transportation. Along with discussing issues like range limits and infrastructure constraints for charging, the paper also looks at new developments in the EV sector, such as developments in autonomous driving and battery technology. This paper seeks to advance knowledge of electric vehicle technologies and their potential to completely transform transportation in the future by offering a thorough overview.

Keywords—*Electric Vehicles, Battery Electric Vehicles, Plug-in Hybrid Electric Vehicles, Hybrid Electric Vehicles, Fuel Cell Electric Vehicles, Sustainable Transportation, Charging Infrastructure, Environmental Impact, Battery Technology*.

Introduction

The automotive industry has seen a dramatic shift toward more environmentally friendly transportation options as a result of the quick development of technology and the escalating concerns about climate change. Since they provide a greener option to conventional internal combustion engine vehicles, electric vehicles (EVs) have become a crucial part of this revolutionary journey. EVs are now at the centre of global research, innovation, and policy initiatives due to the urgent need to address the environmental and energy challenges. The EVs play a crucial role in mankind. When it comes to reducing environmental problems, especially air pollution and greenhouse gas emissions, electric vehicles are essential. EVs make a substantial contribution to lowering respiratory ailments, enhancing urban air quality, and halting climate change by eliminating tailpipe emissions. Additionally, they lessen our reliance on the limited supply of fossil fuels, boosting energy sustainability and security. Getting more people to drive electric cars is essential to meeting global climate targets and building a more sustainable future for future generations.

The origins of EVs can be traced to the early 1800s, when pioneers in the field such as Thomas Davenport and Robert Anderson started experimenting with simple electric-powered carriages. But EVs didn't gain popularity until the late 19th and early 20th centuries. Electric cars were competitive with gasoline-powered vehicles at the turn of the 20th century, particularly in cities like New York and Chicago where electric taxis were popular because of their clean and quiet operation.

Gasoline cars eventually overtook their predecessors, even though they had a longer driving range and required less time to refuel. Electric vehicles continued to exist, serving specialized markets such as urban delivery and material handling.

In recent decades, EVs made a comeback with respect to:

- Environmental Concerns: Because of worries about air pollution and climate change, there is a need for greener transportation options.
- Advances in battery technology: Lithium-ion batteries, in particular, have made EVs more economical and efficient.
- Government Support: To encourage the adoption of EVs, several governments provided incentives and regulations.
- Technological Advancements: Regenerative braking, faster charging infrastructure, and more efficient electric motors increased the usefulness of EVs.

Researchers have extensively studied electric vehicles focusing on areas such as:

- Battery Technologies: Investigating ways to enhance the energy density, longevity, and charging capabilities of lithium-ion and other battery types.
- Charging Infrastructure: Research on extending smart grid technologies and charging networks to facilitate the widespread use of EVs.
- Electronics and Electric Motors: Research into improved motor architectures and energy-management programs for maximum vehicle effectiveness.
- Sustainability: Evaluation of the environmental advantages of EVs, such as lower emissions and their effects on the electrical grid and battery supply chain.
- Policy and Regulations: Examining the impact of regulations, subsidies, and emissions standards on the adoption of electric vehicles.
- Market Trends: Research on consumer behaviour and market dynamics to comprehend the adoption trends of electric vehicles and their financial ramifications.

This synopsis demonstrates various improvements in the field of electric vehicle. Gaining an understanding of this history is essential to appreciating the current situation of electric cars and their bright future in the transportation industry.

Types of Electric Vehicles:

There are several types of EVs, each with unique features and uses.

The main categories of electric vehicles

- Battery Electric Vehicles (BEVs),
- Plug-in Hybrid Electric Vehicles (PHEVs),
- Hybrid Electric Vehicles (HEVs),
- Fuel Cell Electric Vehicles (FCEVs)

Every type of EV advances environmentally friendly and sustainable mobility.

A. Battery Electric Vehicles (BEVs)

Rechargeable batteries provide all of the power for battery electric vehicles, or BEVs. They work by transforming the electrical energy that is stored in the battery into mechanical energy so that the car can move forward. The electric motor, power electronics, battery pack, and charging port are essential parts of a battery-electric vehicle (BEV).

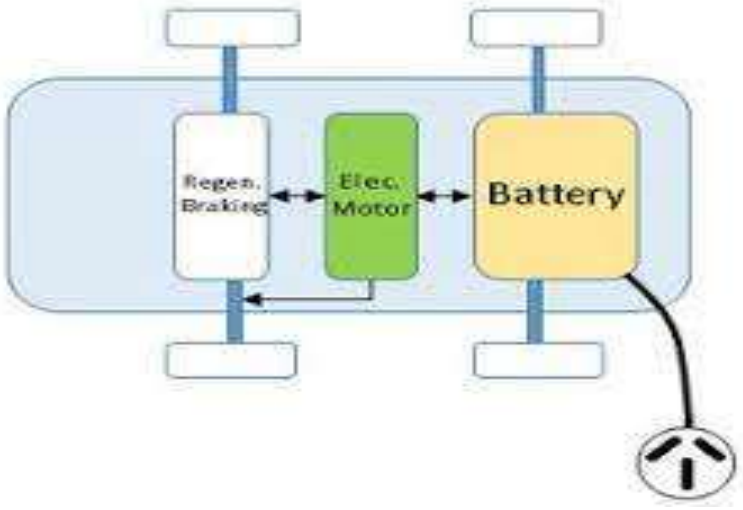

Figure 1.Battery Electric Vehicle

The figure-1 above depicts Battery electric vehicle. Since BEVs require access to electricity to recharge their batteries, the infrastructure for charging them is crucial. BEVs have the advantages of quiet operation, no tailpipe emissions, and cheaper running costs. Nevertheless, their range and infrastructure for charging are constrained, which could pose problems for extended travels and re-fueling intervals.

B. Plug-in Hybrid Electric Vehicles (PHEVs)

PHEVs, or plug-in hybrid electric vehicles, combine an electric motor, a rechargeable battery, and an internal combustion engine. When necessary, they can transition from running entirely on electricity to using an internal combustion engine after a predetermined distance. Because of their

longer driving range, plug-in hybrid electric vehicles (PHEVs) can be used in a variety of driving situations. They can increase efficiency even further by recharging their batteries through regenerative braking. PHEVs provide flexibility and lower emissions while serving as a transitional vehicle between conventional and fully electric vehicles. The figure-2 below depicts Plug-in Hybrid Electric Vehicle.

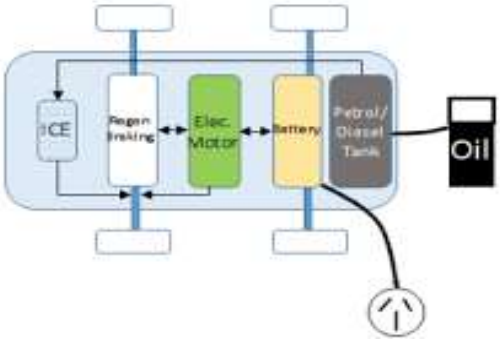

Figure 2.Plug-in Hybrid Electric Vehicle

C. Hybrid Electric Vehicles (HEVs)

Hybrid electric vehicles (HEVs), combine an electric motor and internal combustion engine, but they don't need to be charged externally. Regenerative braking is how HEVs produce electricity. This electricity is then stored in a small battery and used to help the internal combustion engine accelerate. When compared to conventional vehicles, they are renowned for their remarkable fuel efficiency and lower emissions. For people who prefer increased efficiency without depending on charging infrastructure, HEVs are a good option.

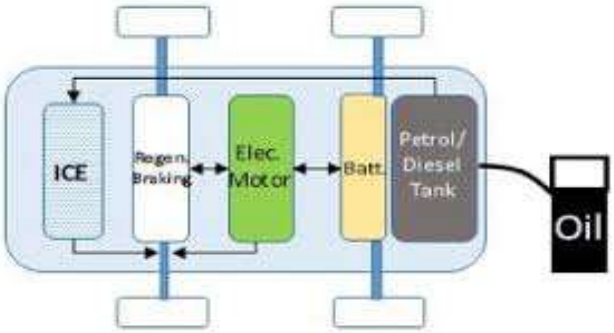

Figure 3.Hybrid Electric Vehicle

D. Fuel Cell Electric Vehicles (FCEVs)

Hydrogen fuel cells are used by Fuel Cell Electric Vehicles, or FCEVs, to produce electricity for an electric motor. These cars are extremely clean and efficient because they only produce water vapor as a byproduct. Compared to many BEVs, FCEVs have longer driving ranges and require only a few minutes to refuel with hydrogen. The lack of a sufficient hydrogen infrastructure and the difficulty of producing hydrogen from sustainable sources remain obstacles. FCEVs have great potential for long-distance, zero-emission transportation.

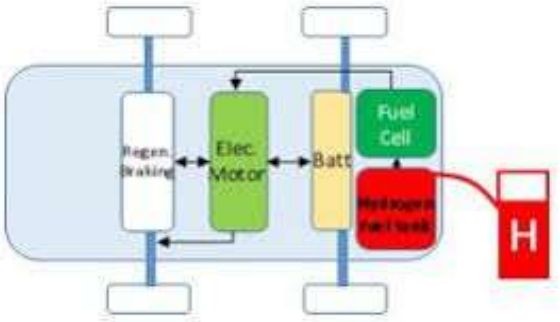

Figure 4.Fuel cell Electric vehicle

Technical Aspects of Electric Vehicles

The electrical energy required for propulsion in an electric vehicle is stored and provided by the batteries, which form its core. The efficiency, range, and charging capabilities of an electric vehicle are all strongly impacted by the battery technology selected. Typical battery technologies found in electric cars include the following:

Lithium-ion (Li-ion): Because of their high energy density, extended cycle life, and comparatively low self-discharge rate, these batteries are used extensively. Li-ion batteries are available in different chemistries, including lithium iron phosphate, lithium cobalt oxide, and others.

Solid-State Batteries: Solid-state batteries, a new and promising technology, have benefits like higher energy density and quicker charging periods. Additionally, they might improve longevity and safety.

Alternative Batteries: In an effort to save costs and increase energy storage, researchers are investigating a number of alternative battery chemistries, such as lithium-sulphur and lithium-air. Comprehending battery technologies is essential since they have a direct impact on the cost, performance, and range of an EV.

COMPARSION OF BEVs AND PHEVs

Zero tailpipe emissions are produced by battery-electric vehicles (BEVs), which run exclusively on electricity stored in batteries. For recharging, they depend on charging stations. Plug-in Hybrid Electric Vehicles (PHEVs) are vehicles that combine an internal combustion engine and an electric motor. After a certain amount of time, they can only operate on electricity. Afterward, they can either use an internal combustion engine or a combination of the two. The table-1. Below compares Battery electric vehicle and plug in hybrid electric vehicle.

Table 1 Comparison Of BEVs And PHEVs

Characteristics	BEV	PHEV
Power source	Electric motor powered by rechargeable battery pack	Electric motor powered by rechargeable battery pack
Fuel	Electricity	Electricity and Gasoline
All-Electric Range	Typically, higher(100+milles)	Limited (Varies, usually 20-50 miles)
Gasoline Range	None	Yes (in addition to electric range)
Charging Infrastructure	Requires charging stations	Can be charges at home or stations
Charging Time	Longer (hours)	Shorter (hours to full charge, or minutes for partial charge)
Emissions	Zero tailpipe emissions	Low emissions during electric mode, higher during gasoline mode
Cost	Generally lower operating costs.	Initial cost may be higher, but may be offset by potential fuel savings.

COMPARSION OF HEVs AND FCEVs

In order to increase fuel efficiency, hybrid electric vehicles, or HEVs, combine an internal combustion engine and an electric motor. They rely on regenerative braking to replenish the battery and do not require an electrical outlet. Fuel Cell Electric Vehicles (FCEVs) produce only water vapor as a byproduct when they use hydrogen fuel cells to generate electricity. Although their range is greater than that of most BEVs, it is still constrained by the accessibility of hydrogen filling stations. The table-2. Below compares hybrid electric vehicle and fuel cell electric vehicle.

Table 2.Comparison Of HEVs And FCEVs

Characteristics	HEV	FCEV
Power source	Gasoline engine and electric	Hydrogen fuel cell stack and electric
Fuel	Gasoline	Motor
All-Electric Range	Limited, higher (short distance)	Typically, higher than PHEVs, similar to BEV (100 miles)
Fueling Infrastructure	Existing gasoline stations	Can be charges at home or stations
Fueling Time	Similar to gasoline Vehicles	Similar to gasoline Vehicles
Emissions	Lower emissions than conventional vehicles	Zero tailpipe emissions
Cost	Generally lower operating costs (low fuel, maintenance)	Higher upfront cost, potential for lower operating costs if hydrogen is affordable.

Charging Infrastructure and Standardsof Electric Vehicles

For EVs to refuel, a charging infrastructure is necessary. The widespread use of electric vehicles depends on the creation of standardized charging infrastructure.

Key aspects of charging infrastructure include:

Charging Levels: Level 1 (120V household outlets), Level 2 (240V charging stations), and Level 3 (fast DC charging) are the different levels of charging stations. The level affects both the power output and charging speed.

Charging Standards: Tesla Superchargers, CHAdeMO, and CCS (Combined Charging System) are just a few of the standards that exist today. The standard selection affects the charging options and interoperability that are available to electric vehicle owners.

Charging Networks: Access to charging stations is made possible in large part by charging networks. To accommodate EVs' rising popularity, businesses like ChargePoint, EVgo, and Electrify America are growing their charging networks. Electric Motors and Power Electronics in EVs

Electric motors, which transform electrical energy into mechanical motion, are a feature of electric vehicles. Important considerations for power electronics and electric motors are as follows. Different motor types are used in electric vehicles, such as synchronous motors, permanent magnet motors, and induction motors. These motors are chosen based on performance and efficiency requirements and have varying characteristics.

Power Electronics: The speed and power of the electric motor are managed by power electronics Among them are converters and inverters, which control how power moves from the battery to the motor.

Regenerative Braking: Regenerative braking systems are a feature of electric vehicles (EVs) that convert kinetic energy into electrical energy, which is subsequently stored in the battery. This technology increases range and improves efficiency.

Environmental Benefits and Challenges of Electric Vehicles

A. Benefits:

- Reduced Greenhouse Gas Emissions: Since electric cars (EVs) emit little to no tailpipe emissions, they contribute to the fight against climate change and air pollution. The type of electricity used for charging determines how much of an emission reduction occurs. There are even more environmental advantages when electricity is generated from renewable resources.
- Energy Efficiency: In general, electric vehicles (EVs) use less energy than conventional cars with internal combustion engines. They use less energy overall because they transform a larger proportion of the electrical energy coming from the grid into power at the wheels.
- Improved Air Quality: Since EVs don't release pollutants like nitrogen oxides (NOx) and particulate matter, they contribute to the reduction of local air pollution. This is especially crucial for cities where air quality is an issue.
- Noise Reduction: Because electric vehicles are quieter than their diesel or gasoline-powered counterparts, noise pollution in urban areas is decreased.
- Resource Efficiency: Even though lithium and cobalt are necessary for EV batteries, recycling and advancements in battery technology can lessen the environmental impact. Furthermore, since EVs have fewer moving parts, they may last longer and produce less waste.

B. Challenges:

- Energy Source: Depending on the electricity source, EVs have different environmental benefits. Some of the benefits of electric vehicles are outweighed by the emissions produced during the electricity generation process if coal or other fossil fuels are the main source of power. To optimize the environmental advantages of EVs, switching to renewable energy sources is essential.
- Battery Production: Because raw materials must be extracted and processed, making lithium-ion batteries for electric vehicles (EVs) can be a resource-intensive and environmentally harmful process. These problems can be lessened by recycling batteries and using better manufacturing techniques.
- Charging Infrastructure: For EV adoption to become widely accepted, the infrastructure for charging them must be expanded. If this expansion is not well-planned, it may have negative environmental effects. The installation and upkeep of charging stations may have an effect on regional energy systems and ecosystems.
- Range Limitations: In general, EVs' shorter range than that of gasoline-powered cars makes them less practical for long-distance driving. Nonetheless, the range of EVs is progressively increasing thanks to developments in battery technology.

C. Future Trends:

Electric vehicles (EVs) have a bright future because of a number of trends that are reshaping the market and encouraging broad use. The ongoing progress in battery technology is one noteworthy trend. The goals of ongoing research and development are to increase the energy density, charging speed, and battery efficiency. With advancements, EVs will be more affordable, have faster charging times, and have longer ranges—all of which have been major barriers to mass adoption. The development of the infrastructure for charging is another important trend. Strong charging networks are being constructed by public and private organizations, along with quick-charge stations beside highways and handy charging locations in cities. In order to reduce range

anxiety and establish EVs as a practical long-distance travel option, this expansion is crucial in motivating consumers to convert from conventional to electric vehicles.

Furthermore, the automotive sector is seeing the rise of novel form factors and vehicle designs. There is a growing variety of electric cars available, from small city cars to SUVs, trucks, and even electric buses. It is now simpler for consumers to locate an EV that suits their lifestyle thanks to the variety of options available, which cater to a range of consumer needs and preferences.

In addition, the EV industry is placing an increasing amount of emphasis on eco-friendly manufacturing techniques and sustainability. In order to lessen the overall environmental impact of EVs from manufacturing to disposal, manufacturers are looking into eco-friendly materials, effective production techniques, and battery recycling methods. The development of autonomous driving features and smart, connected EVs is also being accelerated by collaboration between automakers and technology companies. These developments open the door for EVs to be smoothly incorporated into transportation networks and smart cities in the future, in addition to improving the driving experience. Finally, it is anticipated that global efforts to mitigate climate change and policy initiatives will lead to tighter emissions regulations and increased incentives for the use of electric vehicles. Automakers are being encouraged to heavily invest in electric mobility solutions by the many countries that have set ambitious targets for the phase-out of internal combustion engine vehicles.

To sum up, the future of electric vehicles will be characterized by developments in battery technology, an increase in the infrastructure for charging them, a variety of vehicle options, the use of sustainable manufacturing techniques, integration with smart technologies, and government policies that are in Favor of them. All of these developments point to a time when electric cars are commonplace, completely changing how people commute and drastically lowering the impact of transportation on the environment.

CONCLUSION

This paper provides an in-depth examination of different kinds of electric vehicles (EVs), highlighting their salient characteristics, benefits, and drawbacks. In addition to outlining several different EV categories, such as battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen fuel cell electric vehicles (FCEVs), it highlights the notable shift in the automotive industry towards electric mobility. The study emphasizes how environmental concerns and advancements in battery technology are driving the growing popularity of BEVs, which have zero tailpipe emissions and an increasing range. PHEVs, on the other hand, are becoming more and more popular as a transitional technology because they provide the versatility of both gasoline and electric power, making a wider range of consumers able to use them. Furthermore, FCEVs—which run on hydrogen fuel cells—are seen as a viable substitute, despite certain infrastructure and financial difficulties. The study highlights how EVs can help the environment by lowering greenhouse gas emissions and enhancing air quality. It also discusses the difficulties associated with finding sustainable energy sources and producing batteries. It also discusses the economic benefits of electric vehicles (EVs), including reduced operating expenses, government subsidies, and the effect on the oil sector. Future trends covered in the paper include continued improvements in battery technology, the growth of the infrastructure for charging them, a wider range of vehicle options, environmentally friendly manufacturing techniques, and a rise in support from legislative measures meant to mitigate climate change. The paper concludes by offering a thorough analysis of the state of the industry today and its prospects for the future, highlighting the transformative potential of electric vehicles and their important role in addressing both environmental and financial issues.

References

1. Jiang, D.; Huo, L.; Zhang, P.; Lv, Z. Energy-Efficient Heterogeneous Networking for Electric Vehicles Networks in Smart Future Cities. IEEE Trans. Intell. Transp. Syst. 2021, 22, 1868–1880. [CrossRef]
2. Castro, T.S.; de Souza, T.M.; Silveira, J.L. Feasibility of Electric Vehicle: Electricity by Grid× Photovoltaic Energy; Elsevier: Amsterdam, The Netherlands, 2017. Available online: https://www.sciencedirect.com/science/article/pii/S1364032116305895 (accessed on 15 April 2023).
3. European Commission. Transport in Figures'—Statistical Pocketbook. 2011. Available online:
4. https://ec.europa.eu/transport/f acts-fundings/statistics/pocketbook-2011_en/ (accessed on 21 February 2021).
5. Chan, C.C. The state of the art of electric, hybrid, and fuel cell vehicles. Proc. IEEE 2007, 95, 704–718. [CrossRef]
6. Zhong Du, Leon M Tolbert, John N Chiasson, Burak Ozpineei, Hui Li, Alex Q Huang, "Hybrid Cascaded H-bridges Multilevel Motor Drive Control for Electric Vehicles"
7. Kaijiang Yu, Masakazu Mukai, Taketoshi Kawabe, " A Battery Management System using Non-linear Model Predictive Control for a Hybrid Electric Vehicle" proceeded by 7th IFAC Symposium on Advances in Automotive control the International Federation of Automatic Control Sep 4-7 Tokyo Japan
8. IEEE-USA Board of Directors, "Position Statement: Plug-in Electric Hybrid Vehicle ", 15 June 2007.
9. X. Yu, "Impacts assessment of PHEV charge profiles on generation expansion using national energy modeling system," in Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, 2008 IEEE, 2008, pp. 1-5.

10. IEEE-USA Policy Position Statement, "National Energy Policy Recommendation ". vol. 2009, January 2009.
11. N. Lotfi, M. Ferdowsi, R. G. Landers, “Development of an educational small-scale hybrid electric vehicle (HEV) setup,” IEEE Intelligent Transportation Systems Magazine, vol. 8, no. 2, pp. 8-21, Apr. 2016.
12. Mahmoudi, A. Flah, L. Sbita, “An overview of electric vehicle concept and power management strategies,” International
13. Conference on Electrical Sciences and Technologies in Maghreb (CISTEM), pp.1-8, Nov. 2014.
14. Z. B. A. Mat, Madya, Y. B. Kar, and et al. “Proton exchange membrane (PEM) and solid oxide (SOFC) fuel cell based on vehicles - a review,” IEEE International Conference on Intelligent Transportation Engineering (ICITE), pp.123-126, Sept. 2017.
15. Badin F, Scordia J, Trigui R et al (2006) Hybrid electric vehicles energy consumption decrease according to drive train architec ture, energy management and vehicle use. IET Hybrid Veh Conf 2006:213–223. https://doi.org/10.1049/cp:20060610
16. Sandy Thomas CE (2009) Transportation options in a carbon constrained world: hybrids, plug-in hybrids, biofuels, fuel cell electric vehicles, and battery electric vehicles. Int J Hydrogen Energy 34:9279–9296. https://doi.org/10.1016/j.ijhydene.2009. 09.058
17. Chan CC. The state of the art of electric, hybrid, and fuel cell vehicles. Proc IEEE 2007, 95:704–718.
18. Chan CC. The state of the art of electric and hybrid vehicles. Proc IEEE 2002, 90:247–275.
19. J. C. Gomez andM.M.Morcos, “Impact of EV battery chargers on the power quality of distribution systems,” IEEE Trans. Power Del., vol. 18, no. 3, pp. 975–981, Jul. 2003.