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ELECTRIFIED VEHICLES: FUTURE POTENTIAL AND PROBLEMS

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ABSTRACT

The production of electrified vehicles is experiencing a global expansion, primarily due to their capacity to operate partially or fully without fuel and to emit less harmful gases. The utilisation of electrified vehicles serves to prevent the release of carbon dioxide (CO_2) and other harmful substances into the environment, thereby maintaining air quality. Furthermore, electric motors are more efficient than internal combustion engines (ICE), produce less noise during operation, feature regenerative braking systems, and have a relatively simpler design. However, electric vehicles also have several disadvantages, including limited range for long-distance travel, battery performance degradation in extreme climates, and challenges in battery disposal. This article provides a detailed analysis of the classification of electrified vehicles, the types of batteries used in them, and the advantages and disadvantages of using electrified vehicles in urban environments.

Keywords: electrified vehicles, hybrid electric vehicle, electric battery, charging stations, battery disposal, air cooling, liquid cooling.

INTRODUCTION

An electric motor provides propulsion for electric vehicles and runs on battery power. Electric vehicles are becoming more popular due to their environmental and economic benefits [1, 2]. In many cities, they are needed to address environmental concerns and replace internal combustion engine vehicles. Their use has increased in recent years and is projected to reach 20% of global car sales by 2024 [3].

The production and sales of electric vehicles are experiencing growth in numerous countries, accompanied by the development of infrastructure and charging stations. This will facilitate further expansion of the adoption of electric vehicles in the future in developing countries as well [4].

The rapid growth in the use of electrified vehicles has given rise to a number of challenges, issues and uncertainties, including the high initial cost of such vehicles, the scarcity of charging stations and the limited range of electric vehicles. Consequently, further research is required to improve batteries and simplify the charging process. The primary challenge associated with electrified vehicles pertains to their autonomy. Scientists are engaged in the development of enhanced battery technology to extend driving range while simultaneously reducing weight, cost and charging time. Furthermore, range-extended electric vehicle technologies are also extensively utilised [5].

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ANALYSIS OF RESEARCH

Classification of Electrified Vehicles. Electric vehicles (EVs) are vehicles that operate on electricity. Electrified vehicles feature the option to drive solely on electric energy and can be classified according to their drive technology [6, 7]. The classification of EVs is shown in Figure 1.

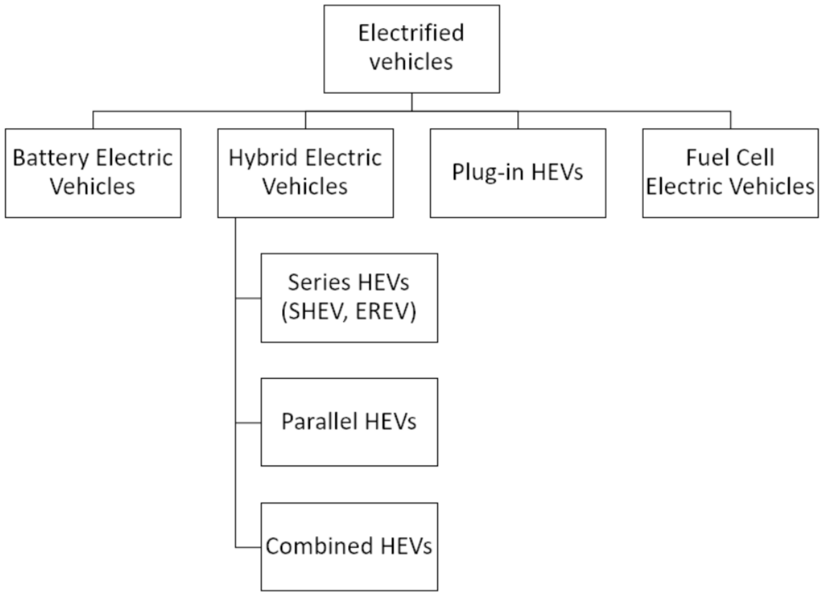

Figure 1. Classification of Electrified vehicles according to engine technology and settings.

Battery Electric vehicles (BEVs): Battery electric vehicles (BEVs) rely exclusively on rechargeable batteries as their traction power source. Unlike conventional vehicles, which are equipped with engines that run on fossil fuels, BEVs do not produce any exhaust emissions. Consequently, these vehicles represent the most ecologically beneficial form of electrified vehicle [6, 7], provided that the electricity is generated from renewable sources. However, the limited driving range of BEVs and resulting range anxiety is main limiting factors for their wide spread [8].

Hybrid Electric Vehicles (HEVs): HEVs are a category of electrified vehicles that employ a combination of electric motors and petrol engines. The energy management strategy of the vehicle's power sources allows for a relatively simple working regime. At low speeds and during acceleration, the electric motor is responsible for propulsion. At higher speeds the petrol engine takes over as it operates in its best efficiency region [7]. When greater power is required, both power sources can participate in traction. HEVs utilise regenerative braking to recharge their batteries, to recover a portion of kinetic energy. Despite their reduced fuel consumption compared to conventional counterparts, HEVs produce some exhaust emissions. HEVs encompass a variety of power source topologies, including series, parallel, and combined schemes [9, 10].

Plug in Hybrid Electric Vehicles (PHEVs): Plug-in hybrid electric vehicles are equipped with the capability of being connected to an external electric power source, which allows for the recharge of batteries with larger capacities than those of HEVs. However, PHEVs have a limited electric operational range in comparison to BEVs. The typical range is between 50 and 120 km, making them a convenient option for daily driving without a plug, particularly for shorter journeys [9].

Fuel cell electric vehicles (FCEVs): Fuel cell electric vehicles represent a significant advance in automotive technology. FCEVs employ a chemical reaction between hydrogen gas and oxygen in the air to generate electric power. They may be operated without a battery and generate only water vapour as a by-product. Despite the advantages of FCEVs, including rapid refuelling and a greater driving range than battery electric vehicles (BEVs), the lack of hydrogen refuelling infrastructure and high-pressure hydrogen storage tanks represent a significant barrier to their adoption [10]. A mass-market example of a fuel cell electric vehicle is the Toyota Mirai [11].

Extended Range Electric Vehicles (EREVs) Extended Range Electric Vehicles (EREV, REX, EVR in short) are a category of electric vehicle that combines the features of BEVs and Series HEVs. The battery pack of an EREV is larger than that of a PHEV but smaller than that of a BEV. This allows the vehicle to travel longer distances on electric power alone. The presence of an internal combustion engine connected to a generator enables the battery to be recharged once it is depleted, thereby extending the driving range as the name suggests [11].
For those considering the purchase of an electric vehicle, the distance that can be travelled on a single charge is a significant factor. The driving range of electric vehicles is contingent upon the capacity of their battery and the efficiency with which they utilise energy.

Battery packs. At present, the most commonly utilised chemistries for battery packs in electric vehicles are lithium or nickel-based. Ultra-capacitors are also becoming a more viable solution as part of hybrid energy storage systems.
A battery is defined as a device composed of electrochemical cells with the capacity to convert chemical energy into electrical energy. Consequently, batteries generate direct current and are utilised for the purpose of powering electric traction.
Given that battery packs are utilised for traction purposes, it is of significant importance to implement effective cooling mechanisms in electric vehicles. This can be achieved through two primary methods: air cooling and liquid cooling.
The principle of convection is employed in the **air cooling** system to facilitate the removal of heat from the battery system. As air passes over the surface, it carries away the heat from the system. Air cooling is a relatively simple method, but it is not particularly efficient in comparison to liquid cooling. Air cooling was employed in earlier versions of electric vehicles, such as the Nissan Leaf. In hot climates, purely air-cooled battery packs in electric vehicles have been shown to present safety concerns. Other car manufacturers, such as Tesla, have demonstrated that liquid cooling is the most effective and safest method [12].
Due to their higher thermal conductivity than air, liquid coolants are highly efficient, offering advantages such as a compact structure and ease of packaging. The use of liquid coolants ensures optimal performance in maintaining the battery pack within the required temperature range, thereby preventing thermal runaways [13]. However, as with all systems

involving liquids, liquid cooling systems present certain safety concerns, particularly regarding the potential for leaks and evaporation. The presence of glycol in the liquid can have adverse effects on the environment if mishandled. To date, these systems have been adopted by some prominent automotive manufacturers, including Tesla, Jaguar, and BMW.

CHALLENGES AND POSSIBLE SOLUTIONS

The utilisation of electric vehicles is not without its challenges and difficulties. The lack of charging stations represents a significant challenge, particularly in regions characterised by low population density [14]. The following section will discuss the challenges associated with integrating electric vehicles into urban environments [15].

Technological challenges [15, 16] include the lack of sufficient charging infrastructure and the needy for fast charging solutions. Additionally, there is a shortage of vehicles with extended range and long charging times. Furthermore, there is an increased strain on the electrical grid, requiring measures to ensure grid stability.

The initial cost of electric vehicles and the expenses of developing charging infrastructure represent a significant **economic challenge**. Moreover, the potential for higher maintenance costs due to the use of new technology adds another layer of financial complexity.

Social challenges include the range anxiety and the adoption of electric vehicles by individuals looking to transition from traditional vehicles.

The environmental impact of battery production and disposal represents a significant **environmental challenge**.

The implementation of government policies and incentives, such as tax credits, subsidies, and grants for purchasing electric vehicles and infrastructure development, along with stricter emission regulations, could encourage the use of electric vehicles.

Technological advancements like batteries with extended ranges and faster charging capabilities, as well as improvements to grid management to handle the charging needs of electric vehicles.

It is similarly crucial to enhance public awareness and education. This can be achieved by providing further information about the advantages of electric vehicles and by challenging and dispelling any misconceptions that may exist. It is similarly important to educate service providers and consumers about the maintenance and use of electric vehicles.

CONCLUSION

The adoption of electric vehicles offers a range of advantages, including: From an environmental standpoint, electric vehicles are a highly beneficial addition. Their electric motors are designed with reliability and minimal environmental impact in mind. Unlike traditional combustion engines, electric vehicles do not emit exhaust gases or carbon monoxide, making them an environmentally friendly choice for urban driving. The convenience of electric vehicles for urban use is evidenced by their ability to travel up to 640 km on a full battery charge. When used correctly and charged on time, electric vehicles are more efficient than internal combustion engine-powered vehicles, provided that the electricity production is mostly from renewable sources. For comparison, the efficiency of internal combustion engines at best is 30%, while electric motor efficiency can reach 90%. Additionally, electric vehicles are quieter during operation and can be made compact, which makes them convenient for city driving.

The initial cost of electric vehicles is typically higher than that of vehicles with internal combustion engines. Additionally, their driving range is often limited, necessitating frequent recharging when driving for extended distances. Furthermore, the performance of electric vehicle batteries may degrade in extreme climates, and there is a risk of battery explosion. Fast charging stations are also a potential concern. These factors collectively contribute to the perceived disadvantages of using electric vehicles.

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