Proceedings of ICEMGD 2024 Workshop: Policies to Enhance Sustainable Development through the Green Economy
DOI: 10.54254/2754-1169/123/2024MUR0123

Types and Challenges of New Energy Vehicles

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Abstract: In the wake of the progressive amelioration of technology, sweeping changes have been brought to modern society. The development and problems of economic and environmental protection have been of concern to many individuals and governments. As a result, the research and invention of new energy vehicles (NEVs) are growing amazingly. This paper has been written to learn more specifics about NEVs. In this paper, there are five sorts of NEVs: Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs), Fuel Cell Electric Vehicles (FCEVs), and Extended-range Electric Vehicles (ER-EVs). Until then, there are four challenges faced by the development of NEVs. The first one is the cost of purchase; the second is the range anxiety; the third is the limited selection; and the last is the charging anxiety. However, the future of new energy vehicles and their market can still be a prospect because many companies are adopting methods to address these problems, such as battery pack and power system distribution, to name just a few, and the percentages of NEV registration are increasing.

Keywords: New Energy Vehicles, Challenges, Prospects.

1. Introduction

With the great expansion of the economy and environment protection, the study and design of new energy vehicle is growing rapidly in the last decade. Especially in 2023, there are 14 million vehicles including hybrid, electric automations registered in the US which indicates the total number of new vehicles increased 53% compared to 2022 [1]. By analyzing these numbers, two main reasons lay the foundation of new energy vehicle development: first is to mitigate global climate changes [2], and second is to alleviate the worldwide energy crisis related to every family's daily life.

The fast energy usage tendency not only consume the fossil fuel storage, but also effects the local environment pollution. For example, more and more countries and regions are having frequent hazy weather which air particles are damaging human health [3]. In additon, the traditional vehicles powered by gas are mainly consuming gas, which is leading the fossil fuel shortage, some countries such as China that 57.8% of oil energy relies on importing may experience a potential risk of energy price changes.

Due to climate pollution created by fossil fuel consumption, people have realized that green energy sources are the only solution to this problem. With the fast speed of new energy vehicle development, scientists indicated that 800 million tons of CO2 emissions would be reduced by 2040, slowing down the global temperature-raising challenge. Therefore, the state gradually advocates for new energy vehicles through subsidies and other means. Today, more and more families are focusing on

DOI: 10.54254/2754-1169/123/2024MUR0123

purchasing new energy cars, which cost less money on daily spending and have more technology equipped. This paper focuses on discussing different types of new energy vehicles development, including working principle, advantages and disadvantages and future prospects.

2. Types of New Energy Vehicles

In the new energy vehicle family, several different types of automation are described by engine methods. Figure 1 shows the classification tress of the electric vehicles [4].

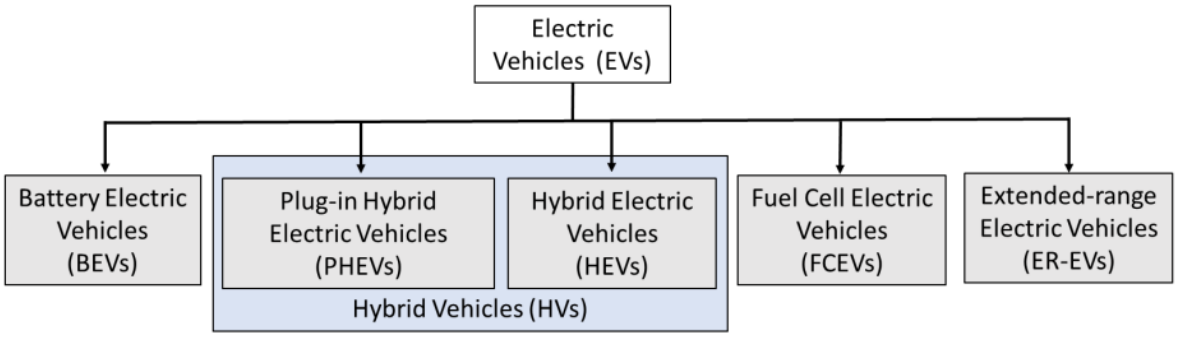

Figure 1: Electric vehicles classification to their engine technologies and settings [4]

Nowadays, people are developing all different kinds of new energy vehicles, however, according to each unique engine technology, all EVs vehicles have their own advantages and disadvantages, in this section we will introduce and discuss each type of design and future marketing situations.

2.1. Battery Electric Vehicles (BEVs)

During 1880s, the very first BEV was built by Gustave et al. [5]. In 1890s, the first practical battery electric vehicle came to the market. The main components of the BEVs are simple, and there are typically 9 sections, as shown in Figure 2.

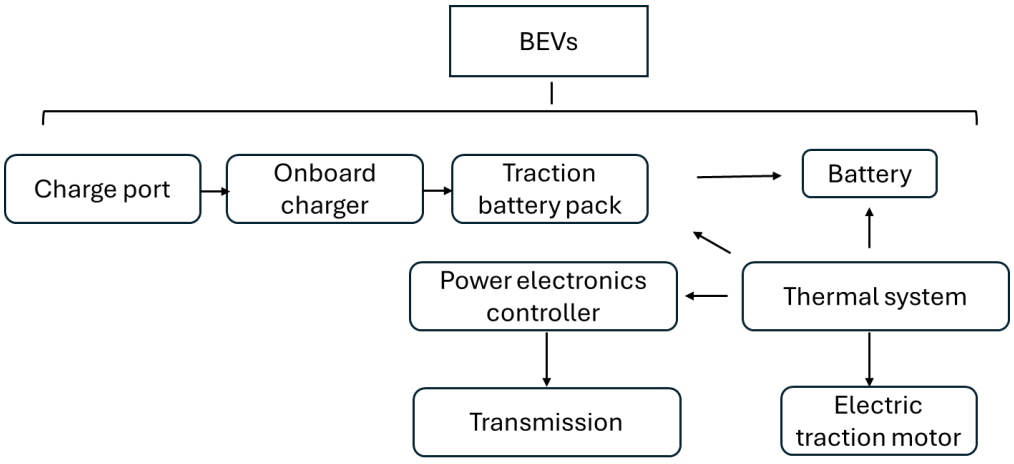

Figure 2: BEVs components [5]

The battery, like traditional vehicles, powers up the vehicle accessories and always has a limited amount of energy storage. For the charge port, it allows the vehicle to connect to an external power supply, such as charging station and stores the energy to the traction battery pack. The DC/DC converter converts the high-voltage source from traction battery pack to low-voltage and power up the motor to achieve vehicle daily driving. The electric traction motor module provides the wheel

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power source and uses the motion-changing behavior between the magnetic coil and DC to create the wheel rotation during vehicle driving. The onboard charger also plays a convertor role, changing the AC power supply to DC power and storing the energy in the traction battery pack. The power electronics controller acts like a traffic coordinator. It will calculate the energy usages and manage the amount of current from battery pack to the motor to control the vehicle speed and torque. In a normal vehicle, all modules need to run at a proper temperature. The thermal system will assume and control the cooling fan low the partial section temperature. For BEVs, the most valuable part is the traction battery pack, this module not only provides the energy to the entire vehicle but also affects the vehicle safety and price. Finally, the transmission module manages the mechanical from motor to the vehicle wheels.

2.2. Plug-In Hybrid Electric Vehicles (PHEVs)

Compared to the BEVs, the Plug-In Hybrid Vehicle is also defined as new energy vehicles. However, besides the mounted traction battery pack, it has an engine system. The PHEVs can take external charging energy from the AC power supply and gas fuel as their energy source for driving, but this technology highly reduces fuel consumption. Due to the design of PHEVs, the whole car components are more complicated than the BEVs. The logic operation system is specially designed by having two motor systems simultaneously, as shown in Figure 3 [6].

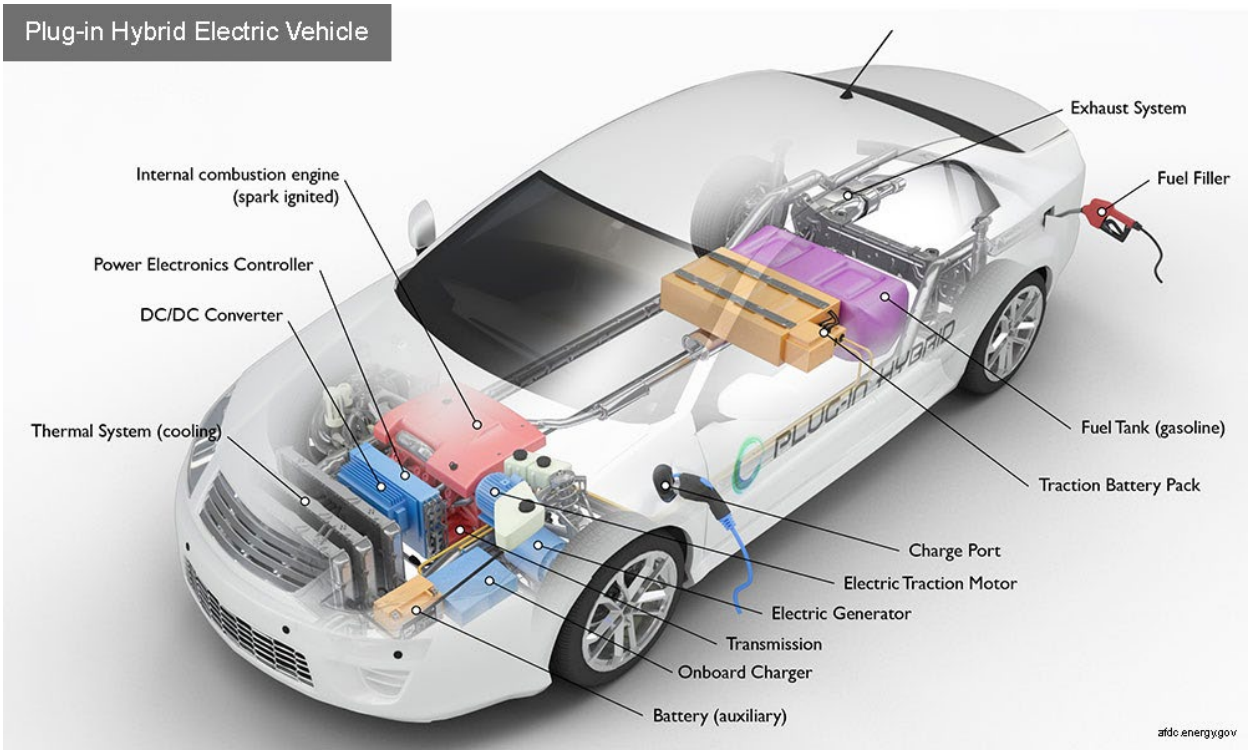

Figure 3: PHEVs system design and components [6]

Because the PHEVs have a traditional engine system loaded, the exhaust system and fuel tank etc. are installed. This may not only consume more space for indoor passengers uses but also reduce the battery capacity, such as the Mitsubishi Outlander only has a 12kWh battery installed [7], but Nissan Leaf, which is 100% BEV, contains a 62kWh battery pack [8].

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2.3. Hybrid Electric Vehicles (HEVs)

There is another type of new energy vehicle called Hybrid Electric Vehicles. It also contains two different power systems: an electric and internal combustion engine. However, the difference between HEVs and PHEVs is that HEVs cannot take external AC power supply charging. In fact, the internal combustion engine charges the battery pack to power up the electric engine. In another word, it only takes gasoline as an energy source. Thanks to the engineer design, this kind of vehicle has a powerful battery recharge system that reverses the energy flow during car barking. For example, Toyota Prius, a pioneer in HEVs market, only has a 1.3kWh battery but the energy-consuming rate is at the same level as other EVs [9].

2.4. Extended-Range Vehicles (ER-EVs)

Theoretically, ER-EVs can not be defined as new energy vehicles because the functional principle was created when electricity was invented using a combustion engine to generate electricity power. However, due to the energy conversion efficiency improvement, less energy loss happened during charging batteries and less fuel consumption. The idea of ER-EVs is also simple: using a small electric generator attached to the battery pack and providing energy during driving. Compared to the PHEVs or HEVs, the engine of ER-EVs is not connected to the wheels of the vehicle. The battery pack size determines the driving range of ER-EVs, therefore the battery size of ER-EVs is larger than PHEVs or HEVs.

Today, when people choose new energy vehicles, they consider their daily costs and worry about their driving range. From this point, more vehicle manufacturers are adding larger gas tanks to the vehicles, which can extend their driving range. For example, the BMW i3 has an internal battery pack which provides 42.2kWh electricity storage for 260km driving range and also installed a fuel tank which allows the vehicle to drive for another 130km [10].

3. Challenges of New Energy Vehicles

The technology for new energy vehicles is not perfect, there are still lots of challenges that BEVs and HEVs are facing.

3.1. Purchase Costs

Compared to the traditional internal combustion engine cars, the purchase cost of the new energy vehicles is higher than the others. The most important part of the new energy vehicles is the battery pack. The statics science shows that more than 40% new vehicles cost for a BEV is the battery pack. In order to support the users' longer driving range, the battery energy density needs to be massive, and the material needed to create it costs more money than traditional vehicle engines. Although the price of the battery material decreases dramatically in recent years, the companies that own the battery pack technology still only occupied a small number of the total market. There is still a long way to go to overcome this challenge. It is very important to have more people involved in the massive battery pack study development, which may create more competitions for battery pack cost to drop.

3.2. Range Anxiety

New energy vehicles have many advantages, such as fast acceleration, advanced control systems and cost-effective driving benefits. However, it has been a long and common discussion topic for new energy vehicle shortage, which is range anxiety. Like the traditional engine-based vehicles, people usually drive their vehicles to every without calculating the distance. The driving range is strictly controlled by the battery size for new energy vehicles, especially the BEV. Due to the battery energy

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density size, the normal BEV can only be continue driven for 300miles. This creates a huge negative impact for new energy vehicle market which people may be concerned about the car's practicability.

Although there are more and more chemical batteries been designed such as lithium iron phosphate ($LiFePO_4$) which the energy density can reach to 220Wh/L, a perfect durability for charging and withstand and a great stability at high temperature environment [11], the issue between driving range and charging speed is still a challenge. And those new types of batteries are still under development mode. For most car companies, lithium batteries are still dominating the market, reducing the users driving range and creating range anxiety. However, to create new elements compound batteries, there are many research institutions such as MIT are changing single chemical element in the lithium-based batteries to improve the energy density storage and charging speed [12].

3.3. Limited Selection

According to the data of US New ten years ago, the type or model of new energy vehicles selling in the US were limited to the Nissan Leaf, Tesla Roadster and Mitsubishi IMIEV. Although the new energy vehicles manufacture has expanded rapidly in recent years, only 28 EV models are available in America from 18 manufacturers.

The selection of BEVs or HEVs are limited to the customers. For example, the sedan vehicles still occupy an large percentage of new energy vehicles. However, people are demanding more functional BEVs or HEVs to be designed such as trucks or minivans.

3.4. Charging Anxiety

Today in many countries, electric vehicles face the same challenges: the charging anxiety. This is not only about the vehicle's charging speed but also the charging station's shortage. There are several studies of the BEVs and HEVs charging station planning behavior proposed by researchers. Hu [13] indicates that the floating car data determine the charging station locations. However, due to the large volume of new energy vehicles development, the number of current charging stations is insufficient to support all users. At the same time, building a new charging station must consider the space, safety and construction time [14]. Charging anxiety is the most important challenge that people need to overcome.

The charging speed is another key point to charging anxiety and range anxiety [15]. There are 3 different levels of charging rate for electric vehicles, shown in Table 1. Most fast-charging stations are at level 2 charging rate, which may take hours for electric vehicles to restore the total energy. Not like the gas station which can fill up a vehicle in 5-10mins, the charging station can only serve a limited number of people. This may also create panic for people when selecting new energy vehicles.

Table 1: Charging time chart [15]

Level	Support Voltage	Charging time
1	120V	20hrs
2	240V	3-4hrs
3	480V	30-60mins

4. Future of the New Energy Vehicle and Market Prospect

Although there are several challenges for new energy vehicles to develop, the future of this new technique is still bright and there is a large volume of needs in automation market. To solve the current BEVs and HEVs problems, many car manufacturers are developing new techniques such as battery

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pack, power system distribution and new energy sources. For example, Tesla has increased the energy recycling system rate up to 92% which may extend the energy usage lifetime.

Besides the BEVs, for HEVs designers, the BYD automation Co Ltd proposed the new generation of hybrid electric vehicles control system, the driving range can be extended to 1200mils per charge and gas fill which double the range compared to the last generation. The total gas consumption reaches to 4.46L/mile and the combined energy efficiency is 46.1% much higher than Toyota.

To avoid charging anxiety, some of the car manufacturers come up with the new idea such as fast battery pack replacement which acts like gas station. Rather than waiting hours for vehicles to fully charge, the drivers only need to drive the car into the battery replacement garage, and it only takes 5~10 minutes to change a new set of battery pack. Also, the replacement process does not involve any labor cost, and it is fully automatic.

On the other hand, the future market space for new energy vehicles is also promising. The growing percentage of new energy vehicle registrations will double in 2023, and the tendency is still increasing. More and more car manufacturers get involved in the new market and change R&D focus to the new energy market. The positive competition between manufacturers may not only accelerate the speed of BEVs and HEVs' development but also decrease costs.

5. Conclusion

All types of new energy vehicle can be classified into 5, namely BEVs, PHEVs, HEVs, FCEVs, and ER-EVs. According to the number of new energy vehicles development, today people are willing to accept this new technology. Although there are many challenges and difficulties for scientists and engineers to overcome in this new field, the future of new energy cars is bright enough.

Although numerous difficulties and dilemmas are faced by new energy vehicles such as the cost of purchase, the range anxiety, the limited selection, and the charging anxiety, they can still be overcome. By having the new energy battery design, charging mode and power control system the fossil fuel consumption rate may dramatically reduce and the new green energy may dominate the world.

There is still a long way to research new energy categories, but eventually, new energy vehicles will play an essential role for the automation industry. In the future, the positive competition between companies that have to do with new energy vehicles will not only facilitate the speed of the development of BEVs and HEVs but also decrease the cost.

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