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AN ANALYTICAL REVIEW AND ANALYSIS ON ELECTRIC VEHICLE BY USING VARIOUS BATTERY TECHNOLOGIES

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ABSTRACT

In terms of greenhouse gas emissions, electric vehicles are thought to be a feasible alternative. Although electric vehicle features and characteristics, as well as charging infrastructure design, have been extensively studied, the development and network modeling of electric cars are still in their infancy. These works are reviewed in detail, and research gaps are identified in terms of theories, modeling methods, algorithms, and applications. A more detailed examination of the global market for electric vehicles and their future prospects is conducted. A complete examination of battery technology, from lead-acid batteries to lithium-ion, is provided in this article. Also included a look at the various standards for EV charging and the proposed solutions for EV power regulation and battery energy management. Lastly, we summarize our work by giving our expectations for this subject in the near future, along with the research elements that are still accessible to both the academic and industrial sectors.

Key terms: Electric vehicle, modeling, battery technologies.

1. INTRODUCTION

In recent years, the automobile sector has become one of the world's most important industries, both economically and in terms of R&D. There are increasing numbers of technology devices being added to automobiles to increase the safety of passengers and pedestrians. It's also easier to get around because there are more automobiles on the road. As a result of this, urban air pollution levels (i.e., pollutants such as PM, nitrogen oxides (NOX), CO, sulfur dioxide (SO2)) have increased dramatically.

GHGs and carbon emissions have been a major concern for policymakers since the Kyoto Protocol was signed in 1998. As much as 98 percent of transportation is reliant on fossil fuels that are very susceptible to fluctuations in energy supply. As a result, governments and automakers are developing economic measures to boost the electric vehicle (EV) market.

One of the AFVs that can help reduce GHG emissions is the Plug-in Hybrid Electric Vehicle (PHEV). Since it can lower gasoline consumption and GHG emissions from 30 to 50 percent without changing the vehicle class, the hybrid gasoline–EV has a lot of promise for the future. But the small battery capacity of EVs prevents them from being widely used. They have cruising ranges of between 150 and 200 kilometers. Who will develop and acquire AFVs without fueling infrastructure in place, as well as who will create the fuelling infrastructure first, continues to be the biggest obstacle.

Advantages over traditional vehicles

EVs offer the following advantages over traditional vehicles:

• **Zero emissions:** Neither CO2 nor nitrogen dioxide is emitted by these vehicles (NO2). Also, the manufacturing procedures tend to be more environmentally friendly, despite the fact that battery manufacturing has a negative impact on the environment.

• **Simplicity:** Due to the lesser number of electric vehicle (EV) engines and components, maintenance costs are reduced significantly. There is no need for a cooling circuit, gearshift, clutch, or noise-reducing devices in the engines.

• **Reliability:** This sort of vehicle has fewer breakdowns because it has fewer and simpler components. There is no natural wear and tear from engine explosions, vibrations, or gasoline corrosion in electric vehicles.

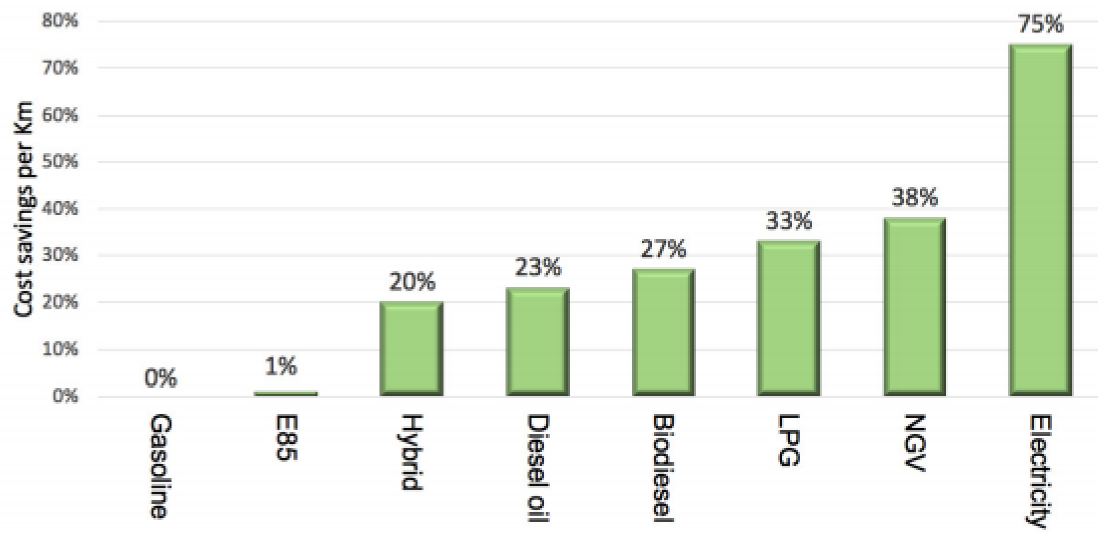

Figure 1. Fuel economy comparison of gasoline, Ethanol (E85), Hybrids, Diesel oil, Biodiesel, Liquefied Petroleum Gas (LPG), Natural Gas Vehicles (NGV), and Electricity vehicles powered by different fuels

• **Cost:** the vehicle's maintenance and electricity expenses are substantially cheaper than those of typical combustion vehicles. Electric vehicles have a lower energy cost per kilometer than conventional automobiles, as demonstrated in Figure 1.

• **Efficiency:** In comparison to conventional vehicles, EVs are more energy efficient. A power plant's efficiency will also have an impact on the overall well to wheel efficiency (WTW). WTW efficiency varies from 11 to 27 percent for gasoline vehicles, whereas diesel vehicles vary from 25 to 37 percent [3]. WTW efficiency of electric vehicles powered by natural gas power plants ranges from 13 to 31 percent, whereas renewable energy-powered electric vehicles can reach 70 percent.

• **Comfort:** EV travel is more comfortable due to the lack of vibrations and engine noise.

2. LITERATURE REVIEW

Electrically powered vehicles (EVs) were originally introduced in 1834, when the first vehicle was unveiled. In 1918, EVs were highly popular, and they could be purchased for a reasonable price. 38 percent were electric, 40 percent steam-driven and 22 percent gasoline-powered cars on the road in 1918. (Rajashekara, 2013). As of the 1930s, the utilization of electric vehicles (EVs) began to decline. Ill-equipped vehicles were a major contributor to their demise. By 1933, the number of electric vehicles had dropped to almost nothing since they were slower and more expensive than internal combustion engines. As early as the early 1970s, electric vehicles encountered a power shortage.

Studies on pure electric vehicles (EVs) included hybrid electric vehicles, pure EVs, and fuel-cell electric vehicles (Frieske et al., 2013). The automotive sector produced more than 350 electric vehicles between 2002 and 2012. Demand for EVs has risen considerably in the last ten years as oil consumption has plummeted and carbon emissions have plummeted, as well as economic growth. As a result, EVs are now more efficient and safer.

When it comes to expanding the usage of EVs in highway traffic, there are two primary areas that must be improved: range and cost. Therefore, numerous efforts have been made to reduce the cost of electric vehicles through the development of simplified speed controllers, battery charging, and new types of cells that can be used. High-energy-density batteries are required for EVs in order to have a longer range. Currently, EVs take an average of 62 kWh to accelerate for 10 seconds at 95.6 km/h (Zhang et al., 2017).

According to the quick decline in EV prices, studies are currently being conducted on many metrics, including driving cost and purchase price as well as ownership expenses (Wu et al., 2015). However, there is no valid reason for why the purchasing price of the EV model declined more fast than that of the other EV models. The cost of the vehicle's performance needs to be investigated further. EVs face a number of challenges, including a shorter driving range than regular vehicles.

There have been a number of studies published on the history of electric vehicles and their development, classifications based on their design and engine characteristics, and an analysis of their influence on the electrical infrastructure. If you look at Yong et al's work, they trace the history of electric vehicles (EVs) from their inception, in the middle of the nineteenth century, till today. In addition, they classify the vehicles based on their powerplant configuration. This study also examines how electric vehicle charging affects the electric grid.

The electric grid's production, efficiency, and capacity are also examined by Richardson. Electric vehicles' economic and environmental impact is also discussed. Electric vehicle charging techniques are examined by researchers Habib et al. Delay loading and clever planning of charges are also examined by the writers. This is followed by an analysis of vehicle-to-grid (V2G) benefits based on charging methods.

3. TYPES OF ELECTRIC VEHICLES

EV, or electric vehicle, is a new kind of transportation that relies on an electric power system. As a result, hybrid and battery electric vehicles (HEVs) and plug-in hybrid electrically powered vehicles (PHEVs) may be categorized as electrified vehicles (Singh et al., 2006). The use of batteries in electric vehicles provides a clear benefit over conventional vehicles. EVs are silent in operation, help to reduce the amount of pollutants that are released into the atmosphere by conventional vehicles, and the most important aspect is that the EV's operating costs are three times lower. Batteries, on the other hand, have a number of drawbacks, such as their heavy weight, expensive cost, and large volume, which severely limits their range, and their performance varies depending on the weather. This is why EVs were briefly discussed for the sake of improving and developing them in the future.

3.1. Battery electric vehicle (BEV)

Only a large battery can power this type of vehicle. It is also possible to charge a BEV via the grid. In the transportation industry, particularly in the realm of electric vehicles, batteries are a key component. We differentiate batteries on the basis of their cost, climate, energy density and power densities as well as their size. In addition, the batteries considerably reduce greenhouse gas emissions and are used in a range of power grid applications that provide high-quality energy obtained from renewable sources such as wind and solar energy, as well as geothermal and other renewable sources of energy. A battery-powered tricycle was first introduced in 1834 as EV

Batteries give BEVs a range of 100-400 kilometers (km). Charging time varies depending on the battery's configuration and capacity. Aside from that, the ambient temperature plays a role as well. Desperately attempting to extend the range of electric vehicles (EVs), we have turned to alternative technologies, such as hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV).

3.2. Hybrid electric vehicle (HEV)

Hybrid refers to a vehicle that is powered by a mix of two or more sources. It has been established in recent years that there are a number of additional hybridization configurations including fuel cell technology, gas turbine technology, pneumatic and ethanol-based fuels and electric drive systems. Electric motors and internal combustion engines (ICs) are the most well-proven and well-established of these approaches. They come in two flavors: a gasoline-powered vehicle that has an engine that acts as a fuel converter, and an electric vehicle with a bi-directional energy storage device. One of the efficiency-improving technologies used in HEVs today is regenerative braking. Traditional IC engines are known to emit a lot of hazardous fumes, waste fuel during high traffic, and many other things according to prior studies. Having switched from an internal combustion engine to a motor-driven drivetrain, HEVs can overcome all of IC engines' shortcomings. For maximum range, the vehicle's fuel tank can be depleted while the vehicle is in motion. Its structure allows it to be divided into three different categories.

i. Series hybrid

When utilized in a series hybrid system, it is also known as a range extender. Fig. 2 illustrates how a combustion engine powers an electric generator, which in turn charges a battery and powers an electric motor For the cars in this system, the only source of electricity is the electric motor.

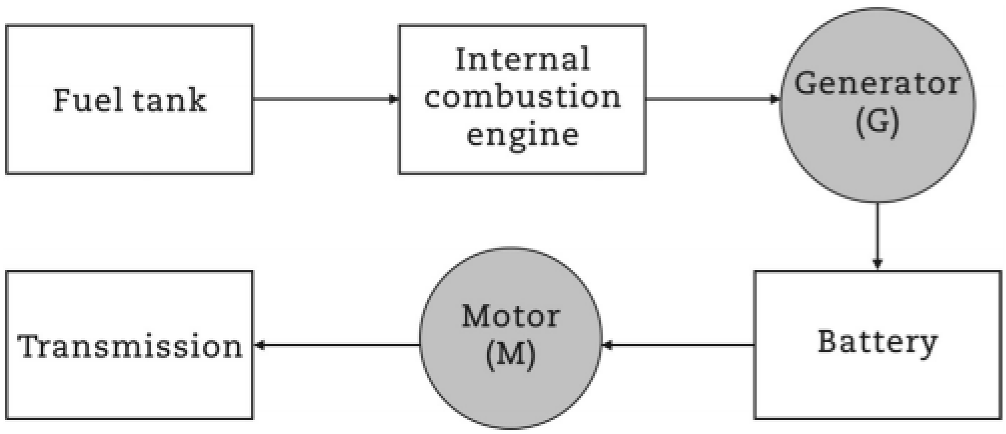

Fig. 2 The Series hybrid electric vehicle

The generator provides power to the vehicle's batteries and motor. There is a massive battery pack in these cars, and a large motor that is driven by a small IC engine. The IC engine and transmission are not mechanically connected in this configuration. As a result, IC can work at full efficiency to meet the vehicle's power requirements. Battery and component costs are the only drawback to this connection.

ii. Parallel hybrid

A parallel connection connects it to an IC engine and an electric motor for mechanical transmission in this configuration. A conventional internal combustion engine (IC) is used as a primary power source, while an electric motor is used as a backup or torque power booster device. This technique has the advantage of using lighter and smaller batteries.

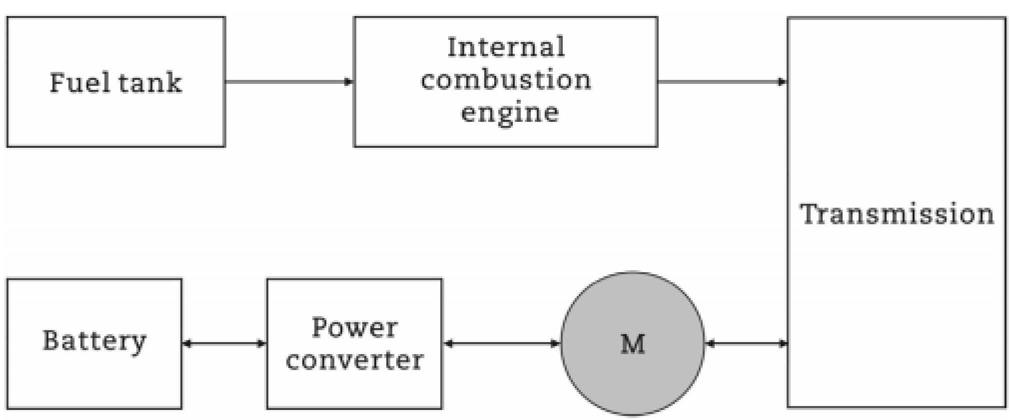

Fig. 3 The Parallel hybrid electric vehicle.

It's possible to recharge the parallel mode batteries during regenerative braking and when travelling at highway speeds As shown in Figure 3, there is a fixed mechanical coupling between the EV wheels and the motor. This means that if your vehicle isn't moving, you can't charge the battery!

3.3. Plug-in hybrid electric vehicles (PHEV)

PHEVs can run on either electricity or gasoline, depending on the model. Their batteries can be charged by plugging into the grid, making them hybrids that can be plugged into the grid. The vehicle's general mode allows for a battery with a middling capacity. Compared to comparable gasoline-powered vehicles, this allows for a range of a few dozen kilometers, as well as great acceleration and high speeds. PHEVs come in a variety of shapes, sizes, and colors. Table 1 lists a few of them.

Table 1 The Comparison study of different PHEVs.

Vehicle model	Range	Price ($)	Charge time (h)
BMW i3 REX	160 km on electric, gasoline	48,950	6
GM Chevy Volt	60 km on electric, 500 km on gasoline	36,895	2
Ford Cmax Energe	34 km on electric, 557 km on gasoline	36,999	2-3

As an alternative to other electric vehicles, PHEVs have a good range, but they have two major drawbacks: 1) they are more expensive than BEVs, and 2) they are not entirely eco-friendly. In the end, battery electric vehicles (BEVs) are the most environmentally and eco-friendly of all the cars. BEVs do not emit any pollutants into the environment, and their only drawbacks are their limited battery range and limited acceleration. To overcome these obstacles, researchers must pay more attention to the future development of batteries. Researchers are now focusing on batteries in general and how they are packaged and tested as well as how their range is developed.

4. METHODOLOGY

Various battery technologies

Lithium-ion batteries

Since lithium-ion batteries make up the majority of electric vehicles now, they are expected to continue to dominate in the next decade. A few of manufacturers, such as Tesla and Nissan, have made significant investments in this field. In the electrolyte, positively charged lithium ions are transported by the anode and cathode Lithium-ion batteries have an extremely poor energy density, which means they can only store very little power, which severely limits their utility. Many manufacturers have attempted to make lithium-ion batteries more stable, as well as created many safety measures to limit harm if a battery were to catch fire because of their reputation for overheating and catching fire (e.g., in Boeing flights, Tesla vehicles, and laptops),

Graphite or silicon anodes with a liquid electrolyte are the most common materials used in LIBs nowadays. Because of its high energy density and small size, lithium anodes have been the holy grail of batteries for a long time.

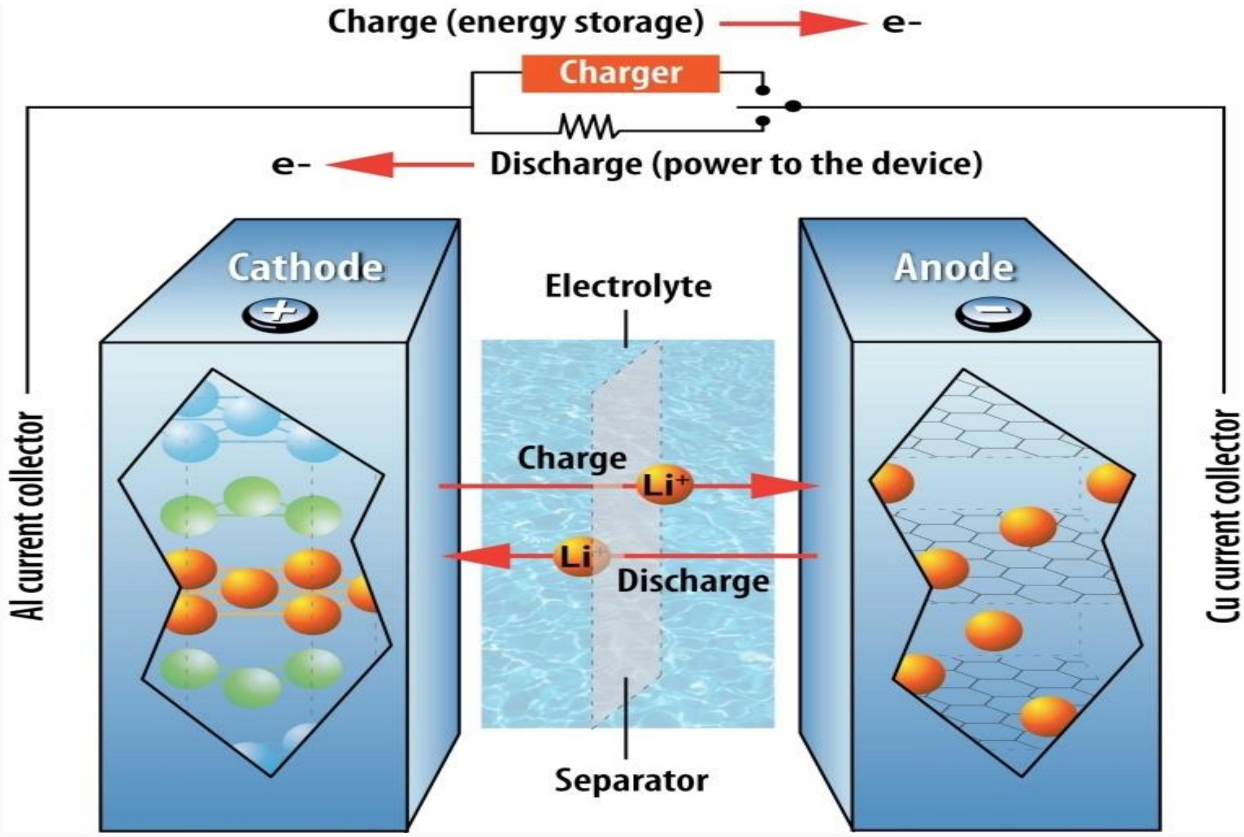

Fig 4: Charge and discharge of a lithium-ion batteries electrons.

Solid state batteries

Components of solid-state batteries can be found in solid state batteries. If you choose a flame-resistant electrolyte, you won't have to worry about electrolyte leakage or fires, and you'll have a longer-lasting system that doesn't require as many costly bulky cooling systems. It can also work in a wide temperature range. Batteries utilizing solid-state technology can benefit from developments made in other battery kinds. GM Ventures and Sakti3 are working together to commercialize solid-state LIBs. In order to power their electric vehicles, Toyota and Volkswagen are looking at solid-state batteries.

Aluminum-ion batteries

Similarly, aluminum-ion batteries use anodes made of aluminum. While the study is still in its infancy, they offer better safety at a lesser cost than LIBs. Anodes made of aluminum and cathodes of graphite helped Stanford scientists overcome one of the aluminum-ion battery's biggest drawbacks: its inability to cycle. Additional benefits include shorter charge times and a flexible device. Researchers at Oak Ridge National Laboratory are working to improve the technology of aluminum-ion batteries.

Lithium-sulfur batteries

Lithium-sulfur batteries (Li/S) have a lithium anode and a sulfur-carbon cathode. Their theoretical energy density is higher than that of LIBs, but at a lower price. Unfortunately, they aren't cyclable due to expansion and hazardous electrolyte interactions. Recent improvements in the cyclability of Li/S batteries have made it possible to use them more than once. The unmanned aircraft Zephyr-6 flew for three days using Li/S batteries and solar panels. In order to power space exploration, NASA has invested in solid-state Li/S batteries, and Oxis Energy is working to commercialize Li/S batteries.

Metal-air batteries

Batteries with a pure metal anode and a cathode of ambient air are known as metal-air batteries (MAF). Cathodes normally weigh a lot in batteries, so having one made of air is a huge advantage. Lithium, aluminum, zinc and sodium are the metals that have the most potential. Rather than using CO2 as the cathode, most experiments use oxygen because it is difficult to collect enough oxygen in the ambient air. Many of these prototypes also have issues with cyclability and longevity.

CONCLUSION

Batteries are often underestimated when they operate as intended, but are slammed when they don't. In no way do the technologies listed above represent all of the advances that have been made in the field of technology. Electrified vehicles will become more widespread as battery technology improves. However, batteries may potentially have a significant impact on global energy markets. If batteries were paired with renewable energy sources, oil, gas, and coal consumption would plummet. Many of the economic and political norms we currently take for granted would be shattered as a result. No need to wait for the "ideal battery" to be developed before we can experience immediate improvements in performance. But even small improvements in the battery industry can have an enormous impact on the world.

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