An Overview of several Advantages and Challenges of Electric Vehicles

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ABSTRACT: Electric vehicles (EVs) are gaining popularity as a result of a number of reasons, including lower prices and increased climate and environmental consciousness. This article examines the advancements of electric vehicles (EVs) in terms of battery technological trends, charging techniques, and new research problems and possibilities. More particularly, a study of the global market condition for electric vehicles (EVs) and their future prospects is conducted. Given that the battery is one of the most important elements of electric vehicles, the article provides a comprehensive overview of battery technologies, ranging from lead-acid through lithium-ion. Furthermore, we examine the various charging protocols available for electric vehicles, as well as ideas for power regulation and battery energy management. Finally, we offer our view of what may be anticipated in the near future in this subject, as well as the research areas that are still accessible to both business and academic groups.

KEYWORDS: Electric Vehicles, Greenhouse Gas, Emissions, Fossil Fuel, Transport.

1. INTRODUCTION

The automotive sector has grown to be one of the most significant industries in the world, not only in terms of economics but also in terms of R&D. More technology features are being added to cars to enhance the safety of both passengers and pedestrians. Furthermore, there are more cars on the highways, allowing us to travel more swiftly and pleasantly. However, this has resulted in a significant rise in air pollution levels in urban areas (i.e., pollutants like PM, nitrogen oxides (NOX), carbon monoxide (CO), sulfur dioxide (SO2), and so on). Furthermore, according to a European Union study, the transportation sector is responsible for approximately 28 percent of overall carbon dioxide (CO_2) emissions, with road transport accounting for more than 70 percent of total emissions. As a result, most industrialized nations' governments are promoting the use of electric vehicles (EVs) to reduce the concentration of air pollutants, CO_2, and other greenhouse gases. They encourage sustainable and efficient mobility in particular via a variety of programs, mostly through tax incentives, purchasing assistance, or other special measures, such as free public parking or free use of highways[1].

Electric Vehicles (EVs) are becoming a potential route for improving air quality, energy security, and economic opportunity in India, thanks to the fast growth of the automobile industry. The Indian government acknowledges the need to investigate sustainable mobility options in order to decrease reliance on imported energy sources, reduce greenhouse gas emissions, and offset negative transportation effects such as global warming. Carbon dioxide emissions may be decreased by adopting preventative steps to avoid catastrophic climate change, which poses a danger to the planet's biodiversity. Major efforts have been made to reduce the use of fossil fuels in power production, transportation propulsion, energy consumption, and carbon sequestration. Electric vehicles (EVs) may be a viable option for reducing carbon dioxide emissions. Even if the usage of electric cars has started, people continue to rely on fossil fuel-powered automobiles. However, as compared to traditional fossil-fueled cars, EVs have difficulties in terms of life cycle assessment (LCA), charging, and driving range.

Electric car manufacturing emits 59 percent more CO2 than conventional vehicle production. On a tank-to-wheel basis, the ICEV emits 120 g/km of CO_2, however this rises to 170–180 g/km when seen through the lens of the LCA. While EVs emit zero CO_2 from tank to wheel, we estimate that the average CO2 is measured throughout a vehicle's life cycle rather than over a single vehicle. The total CO2 emissions from a vehicle throughout its entire life cycle vary considerably depending on the power source used and how the vehicle is operated [2].

1.1 Advantages of Electric vehicles:

EVs offer the following advantages over traditional vehicles:

- *Zero emissions:* These cars do not emit CO_2 or nitrogen dioxide from their tailpipes (NO_2). Furthermore, the manufacturing methods are more environmentally friendly, despite the fact that battery production has a negative impact on carbon emissions.

- *Simplicity:* The number of components in an Electric Vehicle (EV) engine is fewer, resulting in lower maintenance costs. The engines are simpler and more compact; they don't need a cooling circuit, and there's no need to include a gearshift, clutch, or noise-reducing components.
- *Reliability:* Because these cars have fewer and simpler components, they are less likely to break down. Furthermore, EVs are immune to the wear and tear caused by engine explosions, vibrations, and fuel corrosion.
- *Cost:* In contrast to conventional combustion cars, the vehicle's maintenance expenses and the cost of the energy needed are much cheaper. EVs have a much lower energy cost per kilometer than conventional cars.
- *Comfort:* EVs are more pleasant to travel in since there are no tremors or engine noise.
- *Efficient:* Electric cars are more efficient than conventional automobiles. However, the total well to wheel (WTW) efficiency will be influenced by the efficiency of the power plant. For example, gasoline cars' overall WTW efficiency varies from 11 to 27 percent, whereas diesel vehicles' WTW efficiency ranges from 25 to 37 percent. EVs supplied by a natural gas power plant, on the other hand, have a WTW efficiency ranging from 13% to 31%, while EVs fed by renewable energy have a WTW efficiency of up to 70%.
- *Accessibility:* This kind of vehicle enables entry to urban areas where other combustion vehicles are not permitted (e.g., low emissions zones). In big cities, EVs are not subject to the same traffic restrictions as cars, particularly during high pollution levels. Interestingly, according to a new OECD research, EVs will not enhance air quality, at least not in terms of Particulate Matter (PM) emissions.

1.2 Challenges of Electric vehicles:

- *Driving range:* With a full charge, range is usually restricted to 200 to 350 kilometers, but this problem is constantly being addressed. The Nissan Leaf, for example, has a maximum driving range of 364 kilometers, whereas the Tesla Model S has a range of more than 500 kilometers.
- *Charging time:* It takes 4 to 8 hours to fully charge the battery pack. Even a "quick charge" to 80% capacity may take 30 minutes. Tesla superchargers, for example, can charge the Model S up to 50% in 20 minutes and up to 80% in half an hour.
- *The expense of the battery:* Big battery packs are costly.
- *Bulk and weight:* Battery packs are bulky and take up a lot of room in vehicles. The weight of the batteries in this kind of vehicle is estimated to be about 200 kg [8], although this may vary depending on the battery capacity.

EVs, together with shared mobility, public transportation, and other smart city features, will play a significant role in the future years. As a result, additional efforts to make the charging process easier and better batteries are required. The major disadvantage of electric vehicles is their lack of autonomy. Researchers are working on better battery technology to extend driving range while reducing charging time, weight, and cost. The future of electric vehicles will be determined by these variables. Figure 1 represents several types of electric vehicles which have been explained below.

1.3 Classification of the different types of electric vehicles:

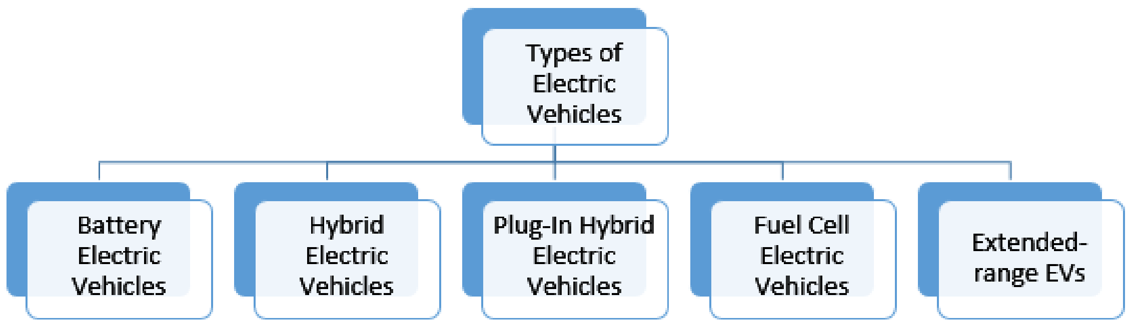

Figure 1: Representation of Several types of electric vehicles.

1.3.1 Battery Electric Vehicles (BEVs):

Vehicles are entirely driven by electricity. BEVs are electric vehicles that do not have an internal combustion engine and do not utilize any kind of liquid fuel. In order to provide a vehicle with sufficient autonomy, BEVs often require huge battery packs. A normal BEV ranges from 160 to 250 kilometers, but some may go as far as 500 kilometers on a single charge. The Nissan Leaf is an example of this kind of car. It is 100 percent electric and presently has a 62 kWh battery that enables customers to go 360 kilometers on a single charge [3].

1.3.2 Plug-In Hybrid Electric Vehicles (PHEVs):

A normal combustible engine plus an electric engine powered by a pluggable external electric source propel hybrid automobiles. In normal driving conditions, PHEVs can store enough electricity from the grid to drastically cut their gasoline usage. The Mitsubishi Outlander PHEV has a 12 kWh battery, allowing it to travel 50 kilometres solely on electricity. However, it's worth noting that PHEVs' fuel usage is higher than manufacturers' estimates [4].

1.3.3 Hybrid Electric Vehicles (HEVs):

Hybrid vehicles use a combination of an internal combustion engine and an electric motor to propel them. The difference between HEVs and PHEVs is that HEVs cannot be connected to the power grid. In fact, the power provided by the vehicle's combustion engine is used to charge the battery that powers the electric engine. The energy created while braking can also be used to charge the batteries in current models, converting kinetic energy into electric energy. In its hybrid form (4th generation), the Toyota Prius had a 1.3 kWh battery that supposedly allowed it to go 25 kilometres in all-electric mode [5].

1.3.4 Fuel Cell Electric Vehicles (FCEVs):

These cars are equipped with an electric motor that runs on a mixture of compressed hydrogen and oxygen taken from the air, with water as the sole byproduct. Although these cars are claimed to have "zero emissions," it is important noting that, although green hydrogen is available, the majority of the hydrogen utilized is derived from natural gas. The Hyundai Nexo FCEV is an example of this kind of car, having a range of 650 kilometers between fill-ups[6].

1.3.5 Extended-range EVs (ER-EVs):

These cars are extremely similar to those classified as BEVs. The ER-EVs, on the other hand, come with a backup combustion engine that can charge the vehicle's batteries if necessary. Unlike the engines found in PHEVs and HEVs, this engine is just utilised for charging and is not connected to the vehicle's wheels. The BMW i3 is an example of this type of car, with a 42.2 kWh battery that provides 260 kilometres of autonomy in electric mode and an extra 130 kilometres in extended-range mode[7].

1.4 Characteristics of the Batteries:

- *Capacity:* One of the major issues with electric power is the complexity and expense of storage. As a consequence, large sums of money are now being invested in the creation of new batteries that are more efficient and reliable, thus increasing battery storage capacity. Under specific circumstances, the battery capacity indicates the greatest amount of energy that can be recovered from the battery. This unit may be represented in either ampere hour (Ah) or watt hour (Wh), but electric cars prefer the latter. Given that the capacity of an electric vehicle's battery is a critical factor because it has a direct impact on the vehicle's autonomy, the development of new technologies that enable the storage of a greater amount of energy in the shortest amount of time will be a critical factor in the success of this type of vehicle.
- *Charge state:* Refers to the battery's capacity as a percentage of its total capacity.
- *Energy Density:* Energy Density is a term used to describe the amount of energy in a Another essential element in the development of batteries is to achieve the greatest energy density possible, which means that a battery of similar size and weight can store more energy. The energy density of a battery is defined as the amount of energy it can provide per unit volume (Wh/L).
- *Specific energy:* The amount of energy a battery can supply per kilogram of mass (Wh/kg). This characteristic is also known as energy density, and it may be measured in Wh/L or Wh/kg.
- *Specific power:* The amount of electricity a battery can provide per kilogram of weight (W/kg).
- *Charge cycles:* When the battery has been utilized or loaded 100 percent, a load cycle is complete

- *Lifespan:* Another factor to think about is the battery's lifetime, which is determined by the number of charging cycles it can withstand. The aim is to develop batteries that can withstand a higher number of charging and discharging cycles
- *Internal resistance:* The components of the batteries are not ideal conductors, meaning that they provide some resistance to the transfer of energy. Some energy is ejected in the form of heat during the charging process (namely, thermal loss). The internal resistance will have a larger effect in high power charges since the produced heat per unit of time is equivalent to the lost power in the resistance. As a result, fast charging procedures will lose more energy than slow charging methods. As a result, it's critical that batteries can withstand rapid charging and increased temperatures caused by internal resistance. Furthermore, lowering this resistance may shorten the charging time, which is now one of the most significant disadvantages of this kind of vehicle.
- *Efficacy:* It is the proportion of power that the battery provides in response to the amount of energy charged.

1.5 Different Components and Battery Types:

1.5.1 Lead-acid batteries (Pb-PbO2):

These are the earliest rechargeable batteries, having been developed in 1859. This kind of battery is often used in conventional cars, although it has also been utilized in electric vehicles. Its specific energy and energy density ratios are very low. A sulfuric acid deposit and a collection of lead plates make up the battery. In the negative plates, lead sulfate is reduced to metal during the first loading process, whereas lead oxide is produced in the positive plates (PbO2). This kind of battery was utilized in cars such as the GM EV1 and the Toyota RAV4 EV.

1.5.2 Nickel-cadmium batteries (Ni-Cd):

These batteries have a higher energy density than lithium-ion batteries, but they have a strong memory effect, a short lifetime, and cadmium is a highly costly and toxic material. Nickel-cadmium batteries are being phased out in favor of nickel-metal-hydride (NiMH) batteries for these reasons.

1.5.3 Nickel-metal-hydride batteries (Ni-MH):

Instead of cadmium (Cd), a hydrogen-storing alloy is utilized for negative electrodes in this kind of battery. Despite having a greater self-discharge rate than nickel-cadmium batteries, these batteries are utilized in many hybrid cars, including the Toyota Prius and the second generation of the GM EV1. Aside from a lead-acid variant, the Toyota RAV4 EV also featured a nickel-metal-hydride version.

1.5.4 Zinc-bromine batteries (Zn-Br2):

These batteries work by storing a zinc-bromine solution in two tanks, with bromide converting to bromine in the positive electrode. In 1993, a prototype known as "T-Star" utilized this technology.

1.5.5 Sodium chloride and nickel batteries (NA-NiCl):

They are also known as Zebra batteries and are quite similar to sodium sulfur batteries. Their benefit is that they can provide up to 30% more energy at low temperatures, despite the fact that their optimal working range is between 260 and 300 degrees Celsius. These batteries are well-suited for usage in electric cars. In 2006, they were utilized by the now-defunct Modec business.

1.5.6 Sodium sulfur batteries (Na-S):

These batteries are made up of sodium liquid (Na) and sulfur (S). This battery offers a high energy density, a high loading and unloading efficiency (89–92%), and a long cycle life. Furthermore, they benefit from the cheap cost of these materials. They can, nevertheless, operate at temperatures between 300 and 350 degrees Celsius. The Ford Ecostar, a vehicle that was introduced in 1992–1993, utilized this kind of battery.

1.5.7 Lithium-ion batteries (Li-Ion):

These batteries use a lithium salt as an electrolyte to supply the required ions for the reversible electrochemical interaction between the cathode and anode. The lightweight of lithium-ion batteries' components, their high loading capacity, internal resistance, and high loading and unloading cycles are all benefits. Furthermore, they have a weaker memory impact.

2. LITERATURE REVIEW

Ricardo J. Bessa et al. discussed Economic and technical management of an aggregation agent for electric vehicles in which they discussed how the anticipated rise in the usage of electric cars (EV) prompted a debate about intermediary organizations that might assist in the management of a large number of EV. A commercial intermediary between a system operator (SO) and a plug-in EV is an aggregation agent for electric cars. The aggregator is seen by the SO as a big source of generation or load that may offer auxiliary services such as spinning and reserve regulation. These services will typically be available in the day-ahead and intraday power markets. Furthermore, the aggregator engages in the electrical market by bidding on supply and demand energy. This article offers a thorough bibliographic review of the function of aggregators in the operation of power systems and the energy market. The study includes 59 references published after 1994 in journals, conference proceedings, theses, research papers, and technical reports. These articles are divided into various groups based on their technical content: aggregation agent idea, function, and business model; algorithms for EV management as a load/resource; electricity market and EV technical and economic problems[8].

Aruna Sivakumar et al. discussed Modelling electric vehicles in The article uses a two-tiered categorization of electric vehicle usage representation, based on time scale and substantial variations in modeling methods, to offer a comprehensive assessment of these various approaches. We find activity-based modeling (ABM) to be the most appealing for time-of-day demand analysis because it offers a framework for integrated cross-sector studies, which is needed for the growing integration of the transportation and energy networks. However, we discovered that existing instances of AMB simulation tool implementation for EV-grid interaction studies had significant limitations. The lack of realism in how charging behavior is represented is one of the most important[9].

Krishnamachar Prasad et al. discussed electric vehicles in which they discussed how Electric vehicles (EV) have been widely studied as a potential method to decrease greenhouse gas emissions. The plug-in hybrid electric vehicle (PHEV) offers competitive driving range and fuel efficiency when compared to internal combustion engine vehicles thanks to advancements in power electrics, energy storage, and support (ICEV). The efficiency of the PHEV may be substantially enhanced by using optimized control methods or the idea of an energy management system (EMS). The operation of different kinds of electric vehicles will be described in this review article. Battery and supercapacitor technologies will also be explored as options for increasing the PHEV's energy capacity[10].

3. DISCUSSION

Electric cars are a viable alternative for decreasing greenhouse gas emissions. Electric cars not only decrease fossil fuel dependence, but they also minimize ozone damaging chemicals and encourage large-scale renewable deployment. Despite extensive study on the features and properties of electric cars, as well as the nature of their charging infrastructure, electric vehicle manufacturing and network modeling continue to develop and be limited. The article covers the various modeling approaches and optimization methods used in studies of Electric Vehicle, Hybrid Electric Vehicle, Plug-in-Hybrid Electric Vehicle, and Battery Electric Vehicle penetration rates in the market. The study is unique in that it addresses key obstacles and inadequate charging facilities for a growing nation like India. When renewable energy sources are unavailable, the development of the innovative Vehicle-to-Grid concept has provided an additional power source. We conclude that considering the unique features of electric cars is critical to their mobility.

4. CONCLUSION

Author examined the many kinds of EVs, the technology utilized, the benefits over internal combustion engine cars, the development of sales over the past few years, as well as the various charging ways and future technologies in this study. We also went through the major research problems and possibilities in depth. In the case of electric vehicles, batteries are crucial since they define the vehicle's autonomy. We looked at a variety of batteries based on these characteristics. Hybrid, Plug-in Hybrid, and Electric Cars may improve vehicle fuel efficiency while also raising the cost of ownership when compared to conventional vehicles. In general, their lower petroleum consumption and higher productivity provide long-term economic benefits to consumers, society, automakers, and politicians. This article offers a comprehensive review of the research, as well as an overview and recommendations for HEV, PHEV, and BEV adoption in India.

Higher-capacity batteries will make it easier to utilize the quickest and most powerful charging modes, as well as more advanced wireless charging technologies. Another element that may help with the adoption of electric cars is the development of a unique connection that can be used worldwide. In the future, electric vehicles will play a critical part in Smart Cities, and having a variety of charging methods that can adjust to the requirements of users will be very essential. As a result, future BMS should take into account the new situations presented by new batteries as well as Smart City needs.

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