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Battery Charging Technologies for Commercial Electric Vehicle and Challenges

Annepu H[1], Vinay Kumar M[2]

[1]Dept. of Electrical and Electronics Engineering, GMR Institute of Technology, Srikaklumam, India hemambariannepu@gmail.com
[2]Dept. of Electrical and Electronics Engineering, GMR Institute Of Technology, Rajam, India vinaykumar .m@gmrit.edu.in

ABSTRACT:

The increasing emphasis on lowering carbon emissions and improving sustainability in the transportation sector has accelerated the widespread adoption of commercial electric vehicles (EVs). This paper provides a thorough analysis of several battery charging technologies, such as opportunity charging, wireless charging, and fast charging, that are specifically designed for commercial electric vehicles. The study looks at the features, benefits, and drawbacks of each charging technology, taking into account things like energy efficiency, infrastructure needs, and charging times. The study also covers the difficulties in implementing these charging technologies in the context of operating commercial electric vehicles, such as cost considerations, interoperability problems, and limitations in grid capacity. It also emphasizes how crucial regulatory frameworks and standards are to enabling the smooth integration of charging infrastructure and guaranteeing the effective and dependable operation of fleets of commercial electric vehicles.In order to encourage the widespread adoption of sustainable and effective charging solutions, this research aims to offer insightful information about the crucial factors influencing the selection and implementation of battery charging technologies for commercial electric vehicles.

Keywords: Electric Vehicle, Electric Vehicle Batteries, Battery charging, Battery Discharging.

I. INTRODUCTION

The process of delivering electric current to a rechargeable battery in order to replace its energy and restore its capacity is known as battery charging. The technology of battery charging has advanced significantly, with advancements concentrated on increasing charging rates, boosting energy economy, and guaranteeing battery longevity. The introduction of smart charging algorithms for optimal performance, the creation of rapid charging solutions that drastically shorten charging periods, and the advent of wireless charging technology, which permits cable-free charging for a variety of devices, are examples of advancements. Furthermore, the development of high-energy density batteries has revolutionized the capabilities of portable gadgets and electric cars, promoting a change toward sustainable energy sources and an environment that uses energy more effectively.There are many different kinds of batteries, such as nickel-metal hydride, lithium-ion, lead-acid, and nickel-cadmium.Every battery has different requirements and charging techniques. It also emphasizes the installation of EV charging stations, highlighting the importance of addressing environmental issues as well as the marketability of these stations.Battery charging technology has come a long way over the years, with the main goals being increased battery lifespan, energy efficiency, and charging speeds.

II. Types of Electric Vehicles

Electric vehicles are rapiadly increasing based on there benefits. It lessens reliance on fossil fuels and is environmentally benign. An electric vehicle (EV) is a car that runs on one or more electric motors that are fed energy from another energy storage device or rechargeable batteries.

i. Battery Electric Vehicles

A Battery Electric Vehicle (BEV) is a state-of-the-art invention in the automotive sector that provides conventional internal combustion engine vehicles with a sustainable and eco-friendly substitute. With the help of a rechargeable battery pack, this kind of electric vehicle runs entirely on electricity to power one or more electric motors. Because BEVs have no tailpipe emissions, they play a major role in lowering air pollution and halting global warming. The development of cutting-edge battery technologies and the construction of reliable charging infrastructures are pushing BEVs into the mainstream and changing the face of contemporary mobility as the global push for greener transportation intensifies By using battery charging to power the vehicle, less fossil fuel is used. The figure 1 below depicts Battery Electric Vehicle.

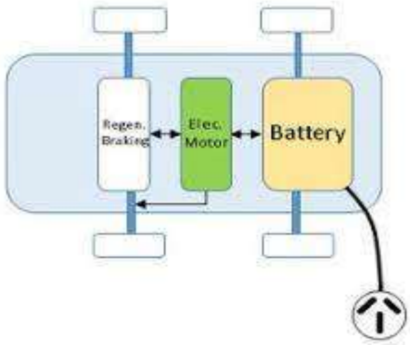

Figure 1. Battery Electric Vehicle

ii. Hybrid Electric Vehicle

An automobile that runs on both an electric propulsion system and an internal combustion engine—typically powered by gasoline or diesel—is known as a hybrid electric vehicle, or HEV. With this dual setup, the car can use the electric motor alone or in conjunction with the conventional engine to maximize fuel economy and minimize emissions. HEVs can run in a variety of modes, such as series mode, where the electric motor provides all of the power, or parallel mode, where both the engine and the electric motor contribute to propulsion. Regenerative braking is often used by HEVs to recharge the electric battery. These cars provide a more environmentally and fuel-efficient driving alternative by acting as a sensible intermediary between conventional internal combustion engines and fully electric vehicles. The figure 2 below depicts Hybrid electric vehicle.

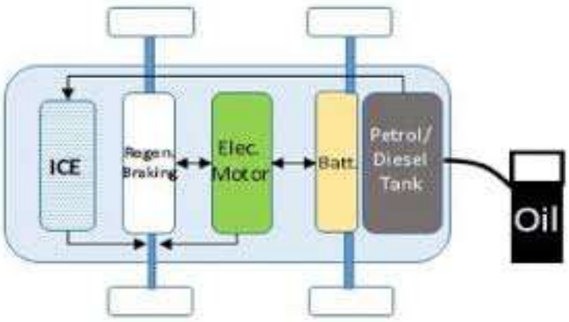

Figure 2.Hybrid electric vehicle

iii. Plug-in Hybrid Electric Vehicle

An internal combustion engine, an electric motor, and a rechargeable battery are all combined in a plug-in hybrid electric vehicle, or PHEV. In contrast to conventional hybrid cars, plug-in hybrid electric vehicles (PHEVs) allow drivers to recharge their batteries while driving and also have the option of charging their batteries externally via an electrical power source. Thanks to this feature, plug-in hybrid electric vehicles (PHEVs) can go a predetermined distance on electricity alone before transitioning to a hybrid mode that draws additional power from the internal combustion engine. When traveling longer distances, plug-in hybrid electric vehicles (PHEVs) combine the convenience and range of an internal combustion improving fuel economy and lowering emissions from exhaust. The figure 3 above depicts Plug-in hybrid electric vehicle.

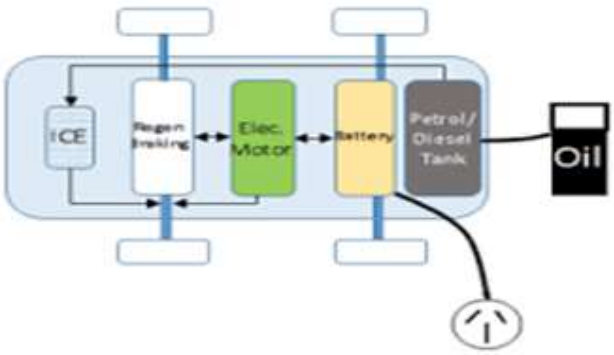

Figure 3. Plug-in hybrid electric vehicle

iv. Fuel Cell electric Vehicle

An electric vehicle that runs on fuel cells to produce electricity s known as a fuel cell electric vehicle, or FCEV. This type of ehicle uses an electric motor to move forward. Fuel cell electric vehicles (FCEVs) use hydrogen gas and oxygen from the air to generate electricity on-board; the only byproducts are heat and water vapor, unlike battery electric vehicles that store energy in batteries. Electricity is produced by the fuel cell's chemical reaction, and this electricity powers the car's electric motor. FCEVs are a promising alternative for clean and sustainable transportation because they have the same benefits as conventional internal combustion engine vehicles, such as quick refueling times and long driving ranges, but they also emit no tailpipe emissions. The figure 4 below depicts Fuel cell electric vehicle.

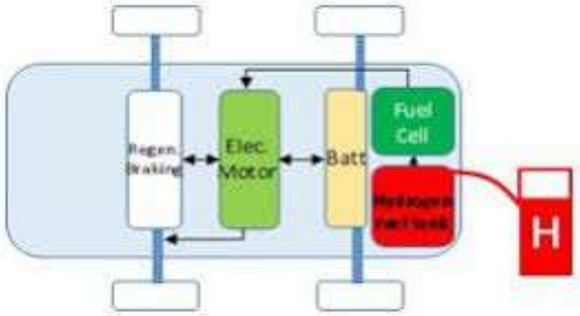

Figure 4. Fuel cell electric vehicle

III. Electric Vehicle Batteries

According to their capacity, batteries are used to store energy. Different battery types, such as lead-acid, lithium-ion, zebra, and nickel-metal hydride, can be used to store energy.

i. Lead-Acid

The earliest, least expensive, and, historically, most widely available car batteries are lead-acid batteries. Lead-acid batteries come in two primary varieties: deep cycle batteries and starter batteries for cars. While deep cycle batteries are used to continuously supply electricity to power electric vehicles like golf carts and forklifts, automobile engine starter batteries are made to use a small portion of their capacity to provide high charge rates to start the engine. Modern electric vehicles do not use lead-acid batteries because of a number of drawbacks, including low energy density, heavy weight, limited cycle life, and slow charging.

ii. Nickel-metal hydride

In the past, electric vehicles (EVs) and hybrid electric vehicles (HEVs) have utilized nickel-metal hydride (NiMH) batteries; however, in the present automotive industry, lithium-ion batteries, which have more advanced technology, have largely surpassed NiMH batteries. Because of their extended cycle life, high power output, and relative energy density, NiMH batteries were preferred for use in some hybrid and early electric vehicle models. At the time, they were also thought to be less costly in comparison to other cutting-edge battery technologies.

iii. Zebra

Zebra batteries are a type of high-temperature battery that functions at temperatures between 270 and 350 degrees Celsius. They are also referred to as sodium-nickel chloride batteries. These batteries have a special set of benefits, including high energy density, quick charge and discharge rates, and a long cycle life. They use molten salt as the electrolyte. Their ability to endure repeated deep discharges without experiencing notable deterioration further qualifies them for use in some electric vehicle (EV) applications.

iv. Lithium-ion

With regard to electric vehicles (EVs), the automotive industry has undergone a radical change with the introduction of lithium-ion batteries. Many contemporary electric vehicles run mostly on lithium-ion batteries, which are well-known for their high energy density, lightweight construction, and long cycle life. Electric vehicles are a viable and sustainable replacement for conventional internal combustion engine vehicles because of their capacity to store significant amounts of energy within a small, effective frame. This allows for longer driving ranges and quicker charging times. This innovative technology keeps pushing the electric vehicle (EV) market forward and aiding in the global development of greener transportation options.

IV. Electric Vehicle Charging Technology

The classification of the electric vehicle technology is explained below. The figure 5 below depicts Classification of Charging Technology.

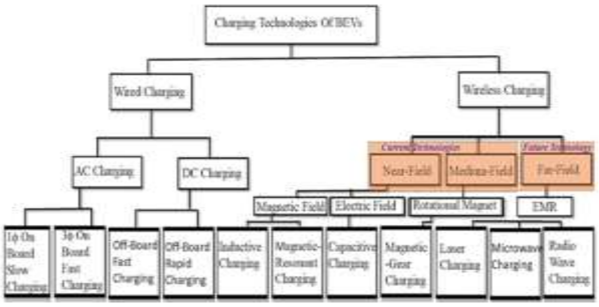

Figure 5. Classification of Charging Technology

A. Wired Charging

In electric vehicles (EVs), "wired charging" is the process of recharging the battery by physically attaching the vehicle to an external power source using a cable. Using a charging cable with the right connectors, you plug the EV into an electrically powered charging station that is compatible with this method. There are three different levels of wired charging: DC fast charging (using specialized high-power charging stations), Level 2 charging (using specialized EV charging equipment), and Level 1 charging (using a standard household outlet). In order to facilitate the widespread use of electric vehicles, wired charging is a popular method used in both home and public charging environments. It provides EV owners with a dependable and effective means of recharging their vehicles' batteries. The figure 6 below depicts Wired charging.

Figure 6. Wired charging

i. AC Charging

When an electric vehicle (EV) is being charged with an alternating current (AC) power source, it is referred to as AC charging. This kind of charging, which is popular in both home and business environments, entails using an AC charging station and a charging cable to connect the EV to an AC power source. Different charging levels can be offered by AC charging stations; Level 1 charging can be done with a regular household outlet, while Level 2 charging can be done with specialized EV charging equipment that offers faster charging speeds. The ability to recharge an electric vehicle (EV) while parked at different locations or during daily use is made convenient for EV owners by the widespread availability of AC charging. AC charging is essential to enabling the broad use of electric vehicles and advancing environmentally friendly transportation options as the infrastructure supporting them grows. The figure 7 below depicts ON Board Charging

Figure 7.ON Board Charging

ii. DC Charging

The process of quickly replenishing an electric vehicle's (EV) battery with a direct current (DC) power source is known as DC charging. Compared to AC charging, this method enables faster charging times, which makes it particularly advantageous for long-distance travel and quick top-ups while traveling.EVs can quickly refuel their batteries with DC charging stations, also referred to as fast chargers, which are frequently found in public spaces like highways, rest areas, and commercial charging stations. In order to encourage the widespread use of electric vehicles and make long-distance travel convenient and effective, DC charging infrastructure must be widely deployed. The figure 8 below depicts OFF board charging.

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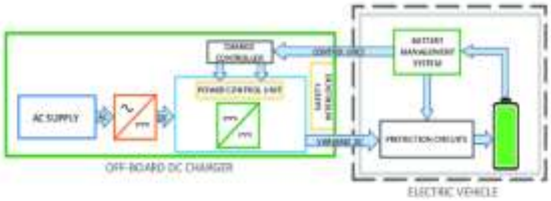

Figure 8.OFF Board Charging

B. Wireless Charging

Electric vehicles (EVs) can now recharge their batteries wirelessly, eliminating the need for physical cables or direct access to a charging station. With this technology, energy is transferred between a receiver mounted in the car and a charging pad on the ground using electromagnetic fields. Convenient and automated charging is made possible by the system, which simply requires the EV to be parked over the charging pad to begin the power transfer. In order to give EV owners an effective and hassle-free charging experience, wireless charging systems are being developed and implemented in a variety of settings, including residential garages, public parking lots, and commercial spaces. The figure 8 below depicts Wireless charging.

Figure 9.Wireless charging

i. *Near Field Charging*:

Inductive charging, or near field charging, is a type of wireless charging that works over short distances, usually a few centimeters. With this technology, energy is transferred between a receiver coil mounted in the car and a charging pad on the ground via electromagnetic induction. Numerous devices, such as smartphones, electric toothbrushes, and some smaller electronic devices, can be charged via near field charging.

ii. *Medium Field Charging:*

In comparison to near field charging, medium field charging entails the transfer of energy over somewhat longer distances, usually between a few centimeters and a few meters. Resonant inductive coupling is frequently used in this technology, giving the charging pad and receiver greater positioning flexibility. Electric vehicle charging is one of the many uses for medium field charging, which will allow for convenient and effective charging without requiring exact alignment of the charging pad with the vehicle or physical connections.

iii. Far –Field charging

An emerging technology called far-field charging, also referred to as long-range wireless charging, allows electrical energy to be transferred over comparatively longer distances, usually tens of meters to several meters. Far-field charging enables the wireless transmission of power between an electric vehicle (EV) and a charging station without the need for physical contact or exact alignment between the charging source and the vehicle, in contrast to near field and medium field charging, which operate over short to moderate distances. The goal of this technology is to make charging EVs more convenient and effective while lowering the need for manual intervention and improving the general accessibility and usability of the infrastructure supporting EV charging.

V. Battery Capacity

The total amount of electrical energy that a battery can store and deliver under particular circumstances is referred to as its capacity. The amount of current a battery can supply over a given period of time or the total power capacity it can deliver in an hour is typically measured in ampere-hours (Ah) or watt-hours (Wh). Estimating an EV's driving range—that is, how far it can go between charges—requires knowing how big of a battery it has. Longer driving ranges are made possible by higher capacity batteries, giving users more flexibility and a reduction in range anxiety. The development of larger capacity and more efficient batteries is still a major area of focus for the electric vehicle industry as it grows, encouraging the widespread use of electric vehicles as a viable and sustainable replacement for conventional internal combustion engine vehicles.

CONCLUSION

Significant advancements in improving charging efficiency, speed, and safety across a range of applications have been highlighted by a recent study on battery charging technology. The research, of particular note, focuses on the creation of high-power charging solutions that allow electric vehicles to be quickly recharged without sacrificing battery longevity. By drastically cutting down on charging times and enhancing user convenience, this innovation solves one of the main issues facing the electric vehicle sector. The study also emphasizes how incorporating renewable energy sources into battery charging technology can improve the efficiency of clean energy storage and utilization. Utilizing cutting-edge smart grid technologies and charging solutions can lessen reliance on conventional power sources and advance sustainability in the energy industry. Notwithstanding these developments, the study notes that more infrastructure optimization, standardization of charging procedures, and cost-cutting measures are required to enable the widespread use and accessibility of advanced charging technologies.

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