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Advancements and Evolution of Electric Vehicle

Uttarala Vamsi[1], *Dr. G. Chandrasekhar*[2]

[1]B. Tech Student, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India

[2] Professor, Department of Electrical and Electronics Engineering, GMR Institute of Technology, Vizianagaram District, A.P, India.

ABSTRACT

The transportation industry, which relies heavily on oil-powered vehicles, is one of the major contributors to the problem of greenhouse gas emissions that face the world today. In order to comply with allowable greenhouse gas restrictionsa lot of research has been concentrated on on the development of electric vehicles (EVs). Even though this field of study is growing, there are still few thorough assessments that capture the entire demand and development of EVs. This comprehensive assessment seeks to close that gap by offering perceptive conclusions about a range of EV development-related topics.

This research provides fascinating insights into the demand and growth for EVs globally, the need for power and batteries, the technological improvements that EVs are currently undergoing, innovations in energy storage, and charging techniques. It also explores how EVs can be integrated into the design of smart cities and looks at the upcoming EV generation, showcasing technology advancements like transfer of power wirelessly. Because there aren't many assessments that thoroughly assess the development of EVs and worldwide demand for them together, this thorough summary is an invaluable tool for academics and policymakers alike. In order to provide investors and politicians with insight into the future of electric mobility, the assessment ends with recommendations.

Keywords: Electric vehicles, Grid integration, Fast charging, Sustainable transportation

INTRODUCTION

Due to advantageous conditions including lower pollution, fuel consumption, increased efficiency, and quieter operation, the adoption rate of electric vehicles (EVs) has increased globally. The current focus of EV research is on developing cost-effective charging solutions, increasing transportation capacity, and improving efficiency. The public's interest increases with decreasing costs, regardless of the type of vehicle—hybrid, modular crossover, or other functional models. Electricity and battery requirements are closely related to current and future global demand, which drives the development of EVs. Improving international standards, EV legislation, all-encompassing frameworks, related components, and user-friendly interfaces are necessary for the development of EVs to be successful. Though road transportation is now dominated by fossil fuels, the widespread adoption of electric vehicles (EVs) appears near. There will likely be a change in favor of electric vehicles during the next ten years.

1. INTRODUCTION TO ELECTRIC VEHICLES

Rechargeable batteries or similar energy storage technologies provide the electricity needed for an electric vehicle (EV) to run. EVs are propelled by electric motors as opposed to conventional gasoline-powered vehicles with internal combustion engines. They have no exhaust emissions, and in order to recharge their batteries, they require an outside power source, such as a charging station. Plug-in hybrid electric vehicles (PHEVs) have electric motors in addition to internal combustion engines (ICEs), while hybrid electric vehicles (HEVs) are primarily powered by internal combustion engines but also have electric motors and batteries for additional power. EVs come in a variety of forms.

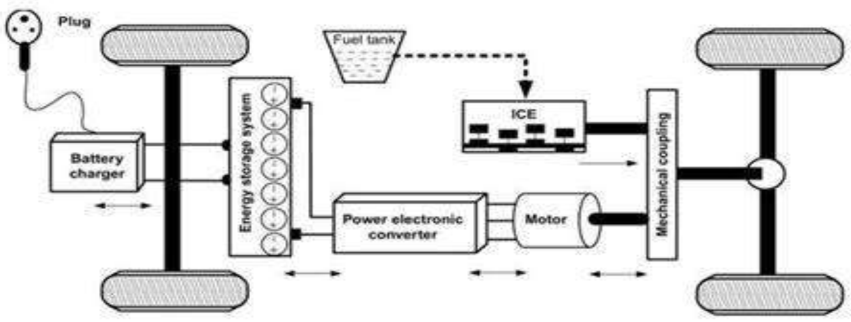

Fig 1: Electric vehicle block diagram

CLASSIFICATION OF ELECTRIC VEHICLES

1.1 Pure EV

An automobile that can store energy in its onboard rechargeable batteries by taking electricity from an external source, such as a wall socket connected to the power grid, is known as a plug-in electric vehicle (PEV). An electric motor is powered by this electrical energy storage, which helps with the vehicle's propulsion. Electric cars (EVs) include electric cars with plug-in hybrids and all-electric vehicles (BEVs). PEVs are a subset of EVs. These cars are a special kind of electric vehicle within the larger category of electric vehicles since they use external power to charge their batteries, which allows the electric motors that drive the wheels to function.

1.2 Hybrid EV

In essence, the power system of an automobile must be able to generate sufficient air pollution, store enough energy to get it through the intended range, and deliver enough power to function. Automobiles that use chemical batteries, hydrogen fuel cells, or gasoline engines can combine multiple energy sources and converters to achieve this., An automobile is considered hybrid when it incorporates two or additional energy sources and transformers. In particular, a HEV is a hybrid car that has an electric drivetrain. No more than two power systems are typically combined for functioning in a hybrid vehicle's drivetrain**.**

1.2.1 Series Hybrid EV

A single electric motor that powers the car is supplied with electricity from two sources in a series hybrid drivetrain. The gasoline tank, which is a one-way energy source, and the engine, which is connected to an electric generator, are the components of the widely used electric powertrain in series hybrid, Through the use of a rectifier, the generator's output is connected to a power bus. A DC/DC converter is used to connect the electrochemical battery pack, which is a bidirectional energy source, to the bus. This electric traction motor, which can function as a generator or motor to provide forward or backward motion, is connected to the electric power bus through its controller. For grid-powered wall plug-in charging, this drivetrain could need a battery charger.

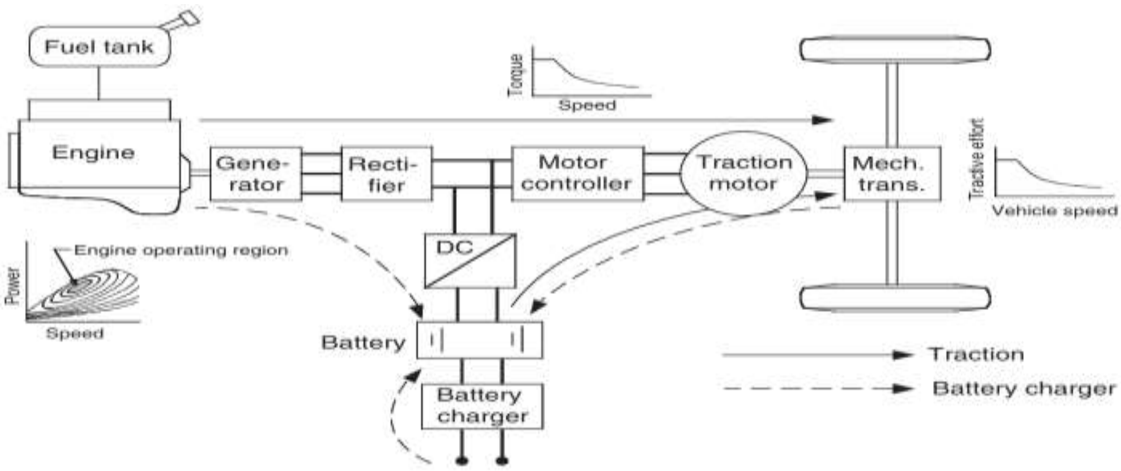

Fig2: 2Series Hybrid EV

1.2.2 Parallel Hybrid EV

A vehicle with a parallel hybrid drivetrain functions similarly to one with a traditional internal combustion engine (ICE), in which the engine powers the wheels directly. Figure 4.3 illustrates how an electric motor that is mechanically attached to the transmission helps with it. The mechanical combination of the engine and electric motor powers allows for a variety of layouts. This arrangement uses a mechanical coupling to combine the forces of the ICE and electric motor, which operate in tandem to propel the car. Nevertheless, the control algorithms of the vehicle become more complex due to this mechanical interaction. Precise power delivery is made possible by the ability to operate the car exclusively with the ICE, exclusively with the electric motor, or with both at once. In comparison to series hybrid electric vehicles (HEVs), removing the generator results in a single-stage power conversion, increasing efficiency while decreasing vehicle weight and cost. The parallel connection of power sources allows for ongoing research and performance enhancement of the vehicle. The current focus of parallel HEV research is on integrating continuously variable transmission (CVT) in place of fixed-step transmissions. This modification allows for greater flexibility in operating the internal combustion engine (ICE) at its most efficient point based on the required torque, fostering further efficiency and performance improvements.

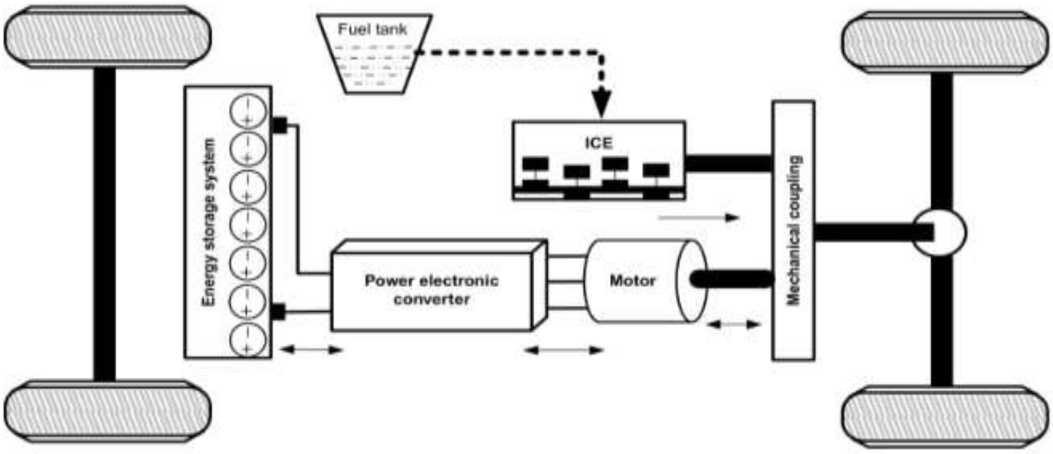

Fig3: Parallel Hybrid EV

1.3 Plug in HEV

Plug-in hybrid electric vehicles are electric vehicles that recharge their battery pack by plugging in and using electricity from an external source, like an internal combustion engine-powered generator. Plug-in hybrid electric vehicles transfer greenhouse gas emissions from the vehicle's exhaust into the generators that power the grid, much like fully electric cars. The central generators can be powered by clean energy sources such as wind, solar, or hydroelectric power, or they can have less overall emissions than individual internal combustion engines.

Fig4: Plug in HEV

1.4 Fuel cell EV

Electric motors powered by fuel cells are produced by fuel cell electric vehicles, which fall under the category of electric vehicles. Their main fuel is hydrogen, which produces energy in the fuel cell by reacting with oxygen. Next, the car is propelled by this power.The only emissions that FCEVs produce are heat and water vapor, which is why they are praised. They can be refueled rather quickly, much like filling up a traditional gasoline vehicle, and have longer ranges than many battery electric vehicles (BEVs). However, the primary obstacle is going to be creating a widely available and accessible hydrogen fueling network as opposed to the more commonplace electric charging stations.

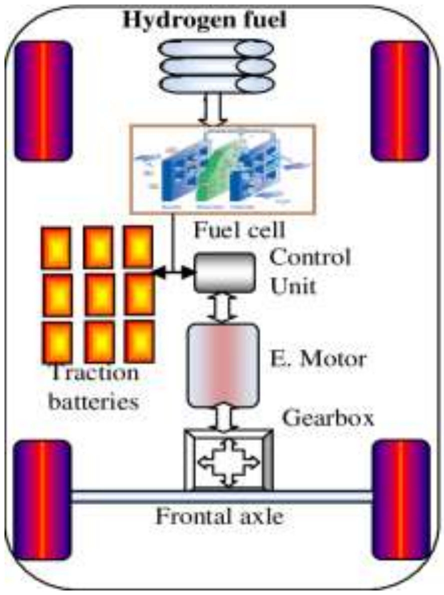

Fig 5:Fuel cell HEV

2 Contemporary Advancements in EV'S

The emergence of electric vehicles (EVs) has generated considerable interest among professionals and institutions worldwide, segmenting the EV market into essential domains essential for thorough data collection. EVs are a source of great pride for the automotive industry because of their low pollution and favorable usage characteristics. They also play a part in the decarborization of transportation by encouraging the growth of low-carbon urban areas. But innovation will play a major role in the EV industry's future prosperity. A number of nations, including Sweden, China, Malaysia, and South Korea, have political stakeholders who are actively creating policies that encourage electric vehicle innovation The topic of technological innovation in the electric vehicle (EV) space is extremely interesting. Figure 5 presents an analysis that highlights the projected improvement rates for power electronics (PE) and electric motors (EM).

3 Versatile and Creative Automobile System

Dynamic Mobility between Plug-in Hybrid Electric Vehicles and Electric Vehicles is an application that is essential to the smart grid space because the benefits of EVs connected to the grid are reciprocal. Furthermore, it frequently fixes issues pertaining to energy. The link between fast vehicle charging and energy consumption in homes or businesses must be made possible by an energy management system. The power control mechanism has two modes of operation: working in tandem with an inverter to transform direct current from a discharged battery into alternating current suitable for a household, or working in tandem with a rectifier to recharge the battery when the current flows in the opposite direction.

4 Upcoming Model of Electric Vehicle Network

Vehicle-to-vehicle, vehicle-to-grid for grid energy storage, and vehicle-to-building (V2B) compliance centers are just a few of the systems that electric vehicles (EVs) integrate into in addition to being used for transportation. Novelties that improve EVs' adaptability and usefulness in contemporary power grids are suggested by recent developments in the EV field. These include projects concentrating on the economical and life-saving elements of the power network, autonomous EVs, wireless power transfer (WPT), and connected mobility (CM). These developments will have a major impact on how the transportation industry develops in the future. The strength and potential for innovation of the automotive industry are greatly impacted by the future electrical transport units' connection to the grid.

5 Good Energy Sources

Analysis of the impacts of EV integration into the grid must take into consideration the role of renewable energy sources and their significant influence when combined with electric vehicle systems. The major objective of this section is to examine the effects of renewable energy sources. The feasibility and challenges of coordinating renewable energy sources, like solar and wind power, to provide energy for charging EV batteries were studied by et al. [52] in order to highlight the goal of lowering greenhouse gas emissions. Controlling the risk of power systems becoming unstable due to an over-reliance on sustainable energy sources is still challenging even with flexible loads in place. Plug-in electric vehicles are most effective when used in conjunction with renewable energy sources or off-peak hours.

6 Advanced design of grid

The electrical grid isn't flexible enough right now. In order to demonstrate the full extent of its operational capabilities, the smart grid, a complex system that is interconnected across all networks, requires effective replication, connection, and validation of various networks. Sadly, not enough attention has been paid to the grid's architectural design. Duplicating, connecting, and validating different network components to guarantee optimal functionality and alignment with the smart grid's overall objectives are key components that are crucial for designing a complex system.

7 Advanced Energy storage systems

In the world of electric vehicles (EVs), battery innovation is still a major focus. The crucial point is at the anode, where particles in the electrolyte move without an electrical voltage as electrons flow towards the cathode. EVs frequently use batteries made of lithium and nickel-metal hydride (NiMH). Lithium batteries power vehicles like the Nissan Leaf and Mitsubishi iMiev, whereas nickel-metal hydride batteries power half of electric vehicles (EVs), like the Toyota Prius. Since batteries are an electric vehicle's only energy source, they must be managed well in order to transfer energy continuously. With the ability to verify extra charge from mechanisms like regenerative braking, monitoring the battery's charge level and making sure it doesn't drop below 20% or rise above 80% is crucial. Ascertaining the battery size entails making sure it approaches the required threshold. As the maximum release rate at 20% of the starting state of charge (SOC) and the maximum state of charge (SOC) at 95%, this limit is defined. The maximum amount of current charge that the battery can have is represented by its charge state, and the maximum amount of released battery level is indicated by its deep discharge. Although the vehicle's battery is its main source of energy for propulsion, it is important for hybrid cars to meet the required battery limit. Smaller battery limits are required for plug-in hybrid car designs that use internal combustion engines to augment pedal force.

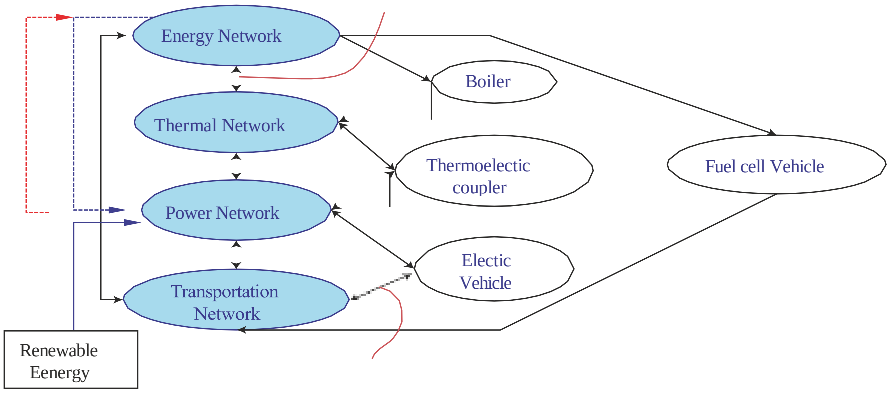

Fig6: Structure of internet

8 Advanced charging techniques

Electricity consumption, accessories, battery types, and power level (kW) are some of the variables that affect how easily electric vehicles (EVs) can be charged. The typical operation of moderate charging is approximately 3.3 kW, whereas fast DC charging can achieve up to 50 kW [55]. Utilizing chargers connected to a level two AC charging station or a traditional single-phase power source is the process of charging electric vehicles (EVs). The development of fully innovative vehicles depends on plug-in hybrid electric cars. For example, in Europe, owners can use external accessories to connect their cars to a standard 230 V AC single-phase outlet and convert the internal devices to DC so that the batteries can be charged. These places frequently have low-voltage setups for charging.

9 Important characteristics of Batteries

A number of factors are included in the fundamental qualities of batteries for electric vehicles (EVs): The maximum extractable energy under specific conditions is indicated by a battery's capacity, which is expressed in ampere-hour (Ah) or watt-hour (Wh). Higher-capacity, more dependable, efficient batteries are sought after because EVs depend on their batteries for autonomy. Automobiles are predicted to soon have batteries that are larger than 100 kWh based on the trend of increased growth.

The charge state of a battery indicates its percentage of full capacity.

10 Energy Density

One important measure of energy density is battery capacity, which is stated as watt-hours per linear liter (Wh/L). Specific energy/power, defined as the quantity of energy a battery produces per unit mass or weight (Wh/kg), is also known as energy density or specific power (Wh/L or W/kg). Specific energy/power (Wh/kg) is the amount of energy that a battery can provide per unit mass or weight. It is also referred to as energy density or specific power (measured in Wh/L or W/kg). Enhancements are meant to make things more durable so that more cycles of charging and discharging can be completed.

11 Internal Resistance

Batteries' intrinsic resistance affects how quickly energy is transferred and charged. Cutting this resistance could shorten the charging time, which is a major drawback for modern EVs. Efficacy is the percentage of power provided in relation to the energy consumed. The goal of improving battery technology is to enable faster charging, higher temperatures, and longer lifespans by raising capacity, decreasing internal resistance, and increasing energy density. These developments are essential for getting over obstacles and improving the efficiency of electric cars.

12 Charging of EVS

The fast and simple charging of electric vehicle (EV) batteries is essential to the general acceptance of EVs, aside from their range. Adoption of EVs depends critically on the establishment of infrastructure for rapid and easy charging. Fast-charging stations along travel routes and home charging facilities are therefore imperative. Charging modes and connectors are two categories under which EV charging technology is governed by multiple standards. There are different areas with different EV charging regulations in place. While China uses GB/T 20234, Europe adopts IEC-62196, and North America and the Pacific region use SAE-J1772, respectively. The former two standards categorize charging modes based on power type (DC or AC), whereas the latter categorizes modes based on charging power. This is the main distinction between the two standards.

- AC Level 1: Uses a 120 V AC standard electrical outlet to deliver up to 1.9 kW of power.
- AC Level 2: Uses a regular 240 V AC outlet with a 19.2 kW maximum power output.
- Level 1 DC: An external charger that can deliver 40 kW of power at 500 V DC and 80 A.
- DC Level 2: A 500 V DC, 200 A external charger capable of producing up to 100 kW.

By providing clarity for users in various regions and accommodating a range of charging needs, these standards and charging modes hope to improve the efficiency and accessibility of charging electric vehicles.

13 Charging case

The starting battery capacity and type of charger used have a significant impact on how electric vehicle (EV) batteries are charged. In general, chargers are categorized into four standard levels, namely Level 1 through Level 4. Electric Vehicle Supply Equipment, or EVSE, or level 1 chargers are commonly used in conjunction with domestic power sources for a large number of electric vehicles. Unlike the in-car chargers in electric vehicles, these chargers typically require seven to nine hours to reach full charge.

14 Effective time of charging

A total of 45% of the battery charge is supplied between 7:00 a.m. and 10:00 a.m., while the remaining 55% is supplied during low usage hours, which are from 10:00 p.m. to 7:00 a.m. Afterwards, around 7:00 and 10:00 a.m. are when 75% of the battery is charged, and no usage occurs during these hours. Given the circumstances, synchronous or initial loading is considered an effective approach that affects energy transaction costs, which gauge battery consumption in the state of charge (SOC). About half of the charging in the uncontrolled state occurs between 7:00 a.m. and 10:00 p.m., and the remaining half occurs during low usage hours. Optimizing the performance of the electric vehicle requires accurate characterization of these conditions.

Completing the assessment requires a precise evaluation of relevant conditions for the electric vehicle. The suggested charging schedule. Limiting connected EV charging during periods of high energy consumption is a major problem with this strategy. The battery pack and its capacity are chosen according to the day type in order to maintain the controlled state of charge. The total load for the night should stay below the scheduled cutoff time if it is possible to prevent the battery from being fully charged overnight. This is dependent on the peak load that is predicted for the next day. With an increased maximum charge capacity of roughly 20 to 30 kWh, upgraded lithium batteries can be used to charge electric vehicles (EVs) with a range of 170 kilometers. EV fuel cell (FC) batteries have a charging capacity of up to 80%.

15 EV'S next generation

Fuel cell vehicles, fuel cell hybrid EVs, hybrid solar EVs, battery electric vehicles, and hybrid electric vehicles are some of the main rivals of internal combustion engine vehicles in the market for electric vehicles. A summary of their assessments of ICE and charging vehicles. When creating advanced, eco-friendly cars with cutting-edge electric drive technologies, particular components should be given priority. It is possible to derive significant authorizations for engine performance enhancement from sources [58–60]. Finding the absolute best technology to use over another is difficult and necessitates a careful analysis of many application-specific factors. When the basic specifications for every kind of EV or HEV are met, it is feasible to determine the crucial characteristics for comparison in order to choose the best

16 Charging Safety Protocol

Since charging an electric vehicle is a special kind of electrical load, safety considerations must be taken very seriously. The distribution network is primarily impacted by the significant volume of electric vehicle charging, though the effects vary depending on the region because of the variety of loads.

Researching charging fault diagnosis and early warning systems is essential to improving safety precautions. This entails looking at fault categories, characteristic values, safety benchmarks, and coming up with effective ways to gather and evaluate data. The accuracy of locating charging faults can be increased by quickly detecting and evaluating issues, along with their causes and suitable solutions. This makes it simpler for maintenance staff to resolve.

Critical indicators include, for example, particular parameters such as temperature and battery voltage variations. Determining these factors' upper and lower operational thresholds aids in determining their typical operating range. Real-time measurements that stray outside of this range automatically stop charging or issue a safety alert, so any potential problems are dealt with right away.

17 General SEMS Scheme

An all-encompassing control system design for the Sustainable Energy Management System (SEMS). A hierarchical control framework that makes use of strategies like rule-based controllers and PID (Proportional Integral Derivative) is necessary to ensure stable mobility. This tier manages a range of components in each apartment to control energy consumption, including electrical switches, boilers, thermosiphons, thermostatic radiator valves (TRV), and relevant resources. A smart city pilot project in China, with important stakeholders including the government, corporations, and people, is depicted technically. Using information and communication technologies to create a cutting-edge infrastructure, it prioritizes smart economy, intelligent management, citizen participation, and services.

Smart infrastructure and ICT-driven management are given priority in smart industrial parks, much like in smart cities. The technical framework of the industrial parks is depicted, which includes smart infrastructure, technology that enhances resource efficiency, and decision support tools for assessment and optimization. This configuration combines modern business models and software tools such as ION for the execution of smart industrial parks with elegant urban industrial designs, effective resource utilization within energy parks, and more.

18 Current research and upcoming trends

Electric vehicles (EVs) are predicted to become more well-known worldwide as a result of technological advancements and their incorporation into renewable energy sources. In order to fully reap the benefits of electric vehicles, technological advancements such as efficient charging protocols, smart city infrastructure, flexible frameworks, improved policies, and CO_2 emission reduction strategies are imperative. Furthermore, an innovative network utilizing contemporary energy frameworks for comprehensive energy computation is the vision for the Energy Internet. This study focuses on market awareness and worldwide adoption while covering every facet of EV development. To assist aspiring experts, a comprehensive examination of EV strategies, parts, charging networks, advantages, disadvantages, and recommendations for additional study is offered. This study also emphasizes the necessity of more research in the EV field in order to explore new avenues and make advancements.

19 V2G and G2V technology

Demand Response (DR) services are made available by Vehicle-to-Grid, or V2G, which connects electric vehicles (EVs) to the electrical grid and permits smart grid functions. It requires the exchange of electricity and related data between grid and transportation systems in order to establish a win-win partnership that advances the development of smart cities. An example block diagram of V2G's structure.

20 Sun to Vehicle

Nowadays, charging stations akin to those for traditional fuel-powered vehicles are essential to the global operation of electric vehicles (EVs). The process of using solar energy to charge electric vehicles through a photovoltaic cell-powered charging station is referred to as S2V or EV-PV charging.. Long-standing solar technologies are the foundation for the application of S2V, or solar-to-vehicle. It is Birnie's research [81] that has primarily popularized the term S2V and highlighted its use. His idea is to charge electric cars that commuters frequently drive by using solar energy collected during the day in parking lots. By converting these solar systems into EV charging stations, carbon emissions are reduced as a result of balancing the load on the electrical grid and reducing dependency on fossil fuels.

Vehicles communicate with infrastructure to exchange data, a concept known as vehicle-to-infrastructure (V2I) in the communications and automotive sectors. This arrangement produces dynamic performance because the vehicle speeds vary. Enhancing road safety and traffic efficiency while reducing environmental impact are two of the main issues that V2I address.

21 Future Recommendations

After reviewing the current state of electric vehicles (EVs), it is clear that new strategies are required to get past development roadblocks. It is difficult to fully address each of these factors in a single study, though. The following suggestions are made for the future to further improve:

(i) Improving standard charging ports and energy storage battery technology are essential for EV adoption in order to maximize user convenience.

(ii) Recycling the materials used in EV batteries presents difficulties and necessitates the development of new energy storage technologies.

(iii) In order to smoothly integrate EVs with renewable energy sources, it is imperative to mitigate the negative grid effects of EV battery charging.

(iv) It might be advantageous to lower the temperature of EV batteries by using air-cooled materials like water or phase-change materials.

22 Dynamic wireless charging

The Dynamic Wireless Charging technology can be used to charge an electric vehicle while it is in motion. The transmitter track consists of multiple transmitter pads spaced along the road; the receiver pad is located beneath the vehicle to give it some ground clearance. Important components of the DWC system are the compensation network, power modulators that regulate input and output power, and charging pads, which are made up of the receiver pad on the vehicle and the transmitter pad on the ground. The various facets of coil design, compensation strategies, and power inverter topologies are shown in Tables 1, 2, and 3, respectively. An energy converter connected to the grid provides power for the Dynamic Wireless Charging system. This Grid-tied DWC system consists of a bridge inverter, an impedance-matching network, charging couplers, an on-vehicle diode rectifier, a grid interface system with Power Factor Correction (PFC), and additional parts. With the grid interface system, power flow from the grid is managed and a constant direct current bus voltage maintained. This voltage of direct current is transformed into high-frequency alternating current by means of a bridge inverter, which causes the receiver coil to spark. The electric vehicle's batteries are then charged by a diode rectifier, which converts the high-frequency a.c. power back into steady d.c.

23 FOREIGN OBJECT DETECTION

Power is transmitted from the road-embedded coils to the receiver coil through the air medium as the alignment passes over them. The strong magnetic field produced by the transmitter coil can transfer power to an object, whether it be metallic or living, when it is placed on it rather than the intended receiver coil. As soon as an object gains sufficient mass, it may unintentionally carry the rated power, which could cause overheating or, in severe situations, even catch fire. Furthermore, foreign objects may cause the coil's inductance parameters to change. In order to detect any foreign objects on the charging pads, it is imperative that a foreign object detection (FOD) system be integrated into the DWC setup.

24 AUTONOMUS DRIVING

We concentrate on autonomous racing cars, but there are other applications for autonomous racing as well, like drone racing. Both combustion and electric engines are possible power sources for these cars, which normally have four wheels. The scale of these could be anything from 1:10 scale cars to real race cars like Formula 1. It must be directly related to the world of auto racing for the hardware and software we cover in our survey. Essentially, this means that the researchers have either used hardware specifically intended for use in racing environments (such as on a racetrack or in an adversarial setup) or have used simulations that represent racecars in racing environments.

25 GLOBAL PLANNING

Research on global planning in racing generally classifies strategies according to different optimization goals, such as reducing energy consumption, optimizing race line geometry, or timing laps more accurately. Through the lap time (tlap) that competing agents achieve, racing provides a concrete indicator of performance quality in this context. Therefore, cutting lap time is frequently the main objective of global planning, which is widely preferred.

Conclusions

This paper is going to focus upcoming trends in Electric Vehicles, it provides various advancements in different areas belongs to EV'S , Significant advancements in electric vehicle (EV) technology have been made, providing encouraging first steps toward environmentally friendly transportation options. The efficiency and accessibility of EVs have increased thanks to advancements in battery storage, smart city integration, and charging infrastructure. Despite these advancements, there are still obstacles to overcome in terms of improving batteries, growing networks of charging stations, and creating laws that encourage broader use. Future prospects for EV technologies are promising, but they will require cooperation. It is imperative to refine charging systems, integrate renewable energy sources, and increase battery efficiency. To achieve these objectives, industry, government, and research organizations must work together. Widespread EV adoption also depends on winning over consumers with improved experiences, longer range, and affordable prices. Several strategies are needed to achieve full EV integration, including changes in consumer behavior, policy reforms, and technology developments. The transition to an electric vehicle-powered, cleaner, more sustainable transportation ecosystem appears more and more possible as these components continue to change.

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