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Expansion of Electrical Vehicles: A Status Report

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A B S T R A C T

Now-a-days, there are a growing number of individuals who care about environmental issues and global warming, both of which contribute to the rising popularity of electric cars (EVs). All throughout the globe, supplies are dwindling due to the increasing demand for non-renewable fuels like gasoline and diesel, which are used mostly in light-duty vehicles. Vehicles that rely on fossil fuels are not only difficult on the budget due to the volatility of fuel costs, but they also pose a threat to health of the public and the natural world. This study examines the evolution of electric vehicles (EVs), focusing on the latest developments in battery technology, converters, charging techniques, connections, and research obstacles. The present and potential EV markets throughout the globe are examined in detail. In electric cars, the battery plays a key role. From lead-acid to lithium-ion, all the different types of batteries are discussed in detail in this study. Moreover, we analyse the various recommendations for regulate power output and manage battery power, as well as the existing requirements for charging EVs.

Keywords:Electric Vehicles; Plug-In Hybrid Electric Vehicle; battery charging; batteries technology; charging modes; EV plugs, Battery management system.

1. Introduction

It's been more than a century since the first cars were built with internal combustion engines, and that's about how long electric vehicles have been on the road. In the early twentieth century, Thomas Edison was the first to suggest the concept of an electric car. Thomas Edison proposed the first electric automobile in the United States in 1886. The world's first battery-powered electric car made its debut in London. In 1889, the term "electric runabout" was first used to describe these vehicles. Due to their lack of noise and emissions as well as their inability to need the assistance of a mechanic to be started, these automobiles were considered to be of the greatest class. Around thirteen businesses produce electric automobiles in Berlin. However, electric starters were available after 1915. There was a general decrease in car accidents with the introduction of internal combustion engines. There has been a decline in the electric car sales. The development of electric automobiles was revived during the 1960s energy crisis. These days, they're mostly thinking about how having a positive environmental benefit scenario might enhance people's quality of life, particularly in cities. Electric cars are clean and efficient, releasing almost no harmful gases into the atmosphere. Power plants make less pollution and less noise than internal combustion engines.

2. Literature review

The development of electric vehicles (EVs) in terms of battery technologies-from lead acid batteries to lithium-ion batteries, charging techniques, as well as new research difficulties and an overview of the current state of the EV market globally. The different charging process available for Evs and also power management and battery energy management.[1].

Transportation electrification has been a major research attention over the last decade. Electric vehicles (EVs) are surpassing conventional internal combustion engine vehicles in market share. The development of EVs leads to an increase in the number of charging stations, which has a significant impact on the electricity grid. Different charging methods and grid integration methods are being developed to minimize the negative effects of EV charging, as well as increasing the benefits of EV grid integration.[2].

It provides a PV-based microgrid daytime charging plan for EVs. the results show that the charging of EV using PV based microgrid in the presence of proposed scheme is more economical as compared to the charging from the standalone generator. Furthermore, the scheme helps the microgrid to reduce EV charging burden on the generator set resulting fuel cost saving.[3].

The battery management system (BMS) is the main safety guard of a battery system for EVs, it is to made reliable and safe operation of battery cells connected to provide high currents at high-voltage (HV). It presents different BMS structures and their applicability to battery systems depending on system size. Further, the typical functions of a BMS are shown with a focus on SoC estimation, detailing various estimation measures.[4].

This analysis provides an overview of the studies of Electric Vehicle, HEVs, Plug-in-Hybrid Electric Vehicle and Battery Electric Vehicle penetration rate into the market and discusses their different modelling approach and optimization techniques. The recent initiatives and various subsidies by the Indian Government will help push the e-mobility drive in India.[5].

The effect of EV wireless charging on clearance reduction in the electricity network is investigated. Furthermore, the impact of transportation network clearance on the economics of the power grid are presented. Finally, there is the effect of battery size on the total travel cost of charged EVs.[6].

Thermal analysis of a Li-ion battery pack is carried out to examine the relationship between battery thermal behavior and design parameters. The efficiency of the battery pack is investigated using various cooling techniques. The efficiency of the battery pack is investigated using various cooling techniques.[7].

It analyzes that present Electric vehicle batteries having the recycling challenges because of their large size, potentially large numbers, uncertain timetable for implementation, and varied chemistries. Most battery chemistries contain materials that would be considered hazardous waste by virtue of reactivity, corrosivity, or toxicity. On disposal, reactivity and corrosivity can generally be dealt with by appropriate treatment of the battery waste.[8].

In order to charge an electric car, there are a number of different standards that have been developed, most of which are dependent on the specific region. The SAE-J1772 standard is used in North America and the Pacific Area to load electric cars. The European Union adopted the IEC-62196 standard, whereas China adopted the GB/T 20234 standard. The biggest difference between the first two standards and the third is that the first two group charging methods by whether they use direct current (DC) or alternating current (AC), while the third groups them by how much power they need to charge.[9].

The microgrid is regarded as the most promising solution for small and remote island power systems. Despite its effectiveness, one of the main concerns is the availability and cost of fuel for its electric generators. In addition, the need to preserve nature, ecological stability, and the environment are all factors that limit the excessive use of fossil fuels This is especially important for an island reliant on tourism as a major source of income at the same time, there is an urgent need for an efficient transportation system. This improves mobility and economic activity. These requirements appear to be incompatible with one another other because transportation necessitates the use of fuel for the generators.[10]

3.Methodology

There have been several breakthroughs in the manufacturing, implementation, and promotion of electric vehicles during the last decade. The increasing emphasis on research has also led to a rise in new job openings and project ideas associated with electric cars. In this section, we will briefly cover the most important issues related to EVs that have been discussed in the existing literature. Some major disparities between the poll and reality are also highlighted. Many nations have announced plans to outlaw the sale and use of vehicles powered by internal combustion engines, so this trend is likely to continue over the next few years. Norway has announced that beginning in 2025, only zero-emission automobiles and trucks will be marketed in the country. In contrast, by 2030, it is anticipated that only electric vehicles would be marketed in the Netherlands, India, and Israel. Germany and the United Kingdom have delayed their deadlines until 2040, whereas California has already prohibited combustion-powered automobiles.

Despite the promising findings, it is important to remember that just 10 countries accounted for 95% of all EV sales (i.e., China, USA, Japan, Canada, Norway, United Kingdom, France, Germany, the Netherlands, and Sweden). Lastly, it's worth noting that BEVs and PHEVs are now on the market. The Tesla Model 3 (BEV), Toyota Prius Prime (PHEV), Chevrolet Volt, Nissan Leaf (BEV), Tesla Model S (BEV), Ford Fusion Energy (PHEV), and BMW i3 are just few examples of popular models that have sold out (BEV).

Table1: Between now and 2020, electric vehicles (EVs) will account for a bigger share of the new car market.

Country	2013	2014	2015	2016	2017	2018	2019	2020
Norway	6.10%	13.84%	22.39%	27.40%	29.00%	39.20%	49.10%	55.90%
Iceland	0.94%	2.71%	3.98%	6.28%	8.70%	19.00%	22.60%	45.00%
Sweden	0.71%	1.53%	2.52%	3.20%	3.40%	6.30%	11.40%	32.20%
USA	0.62%	0.75%	0.66%	0.90%	1.16%	1.93%	2.00%	1.90%
UK	0.16%	0.59%	1.07%	1.25%	1.40%	1.90%	22.60%	45.00%
Japan	0.91%	1.06%	0.68%	0.59%	1.10%	1.00%	0.90%	0.77%
China	0.08%	0.23%	0.84%	1.31%	2.10%	4.20%	4.90%	5.40%

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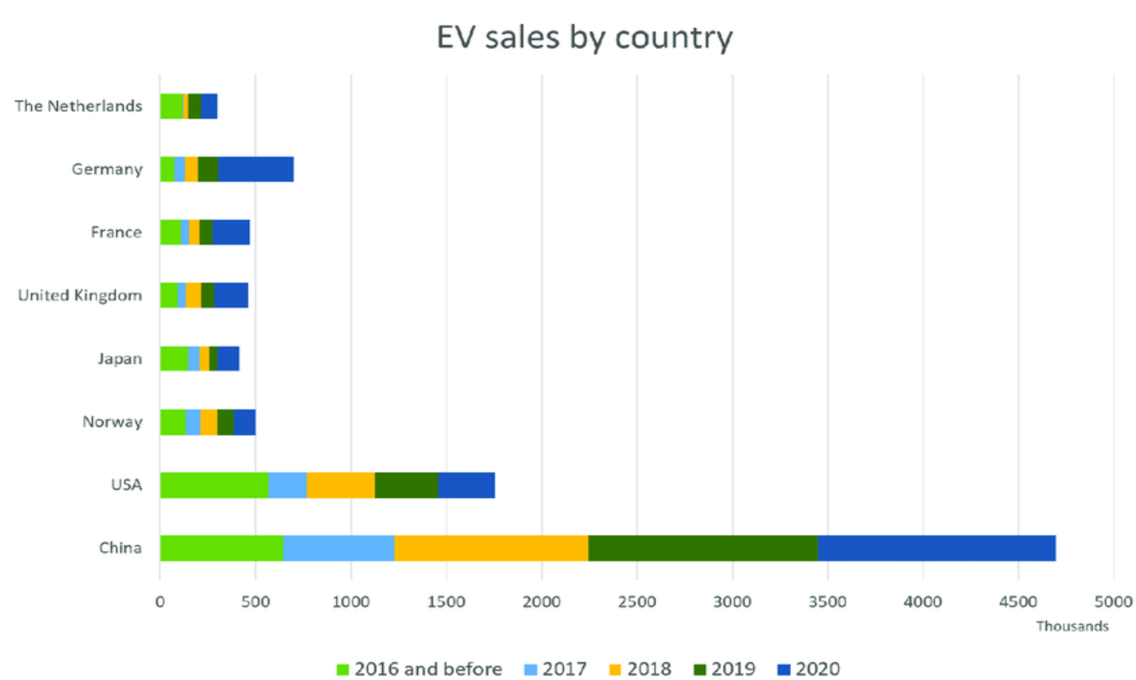

Fig:2. Changes in global sales of electric vehicles

Batteries:

This section talks about the basic parts of batteries, how they are getting cheaper, and some interesting facts about them. It also talks about the different technologies that are now used to make them.

• Capacity: An important difficulty with electrical power is its storage, which is both difficult and costly. So, a lot of money is going into research and development of new batteries that are more effective and reliable, which will increase the amount of energy they can store.

• Charge status. means the percentage of remaining juice in the battery.

• Energy Density: maximizing a battery's capacity to store energy while maintaining its size and weight is another important goal of battery development how much power a battery can hold in relation to its physical size is measured by its "energy density." (in watt-hours per litre).

• Specific power: Means directed force. The energy capacity of a battery is measured in terms of its weight, which is known as its power density.

• Charge cycles: recharge cycles A load cycle is when a battery has been used up or filled to its full capacity.

• Specific energy: focusing on the enthalpy content. how much power a battery can provide relative to its weight (in watt-hours per kilogram). Some writers call this property, which can be measured in Wh/L or Wh/kg, energy density.

• Lifespan: That which determines how long a person lives One further thing to consider is how many times a battery may be charged and discharged. One of our long-term goals is to make battery packs that can be charged and drained more times.

• Internal Resistance: There is a barrier inside oneself. The resistance to current flow in the battery is due to the fact that its constituent elements aren't perfect conductors. When charging, some of the energy is converted to heat. Because the amount of heat made in a given amount of time is proportional to the amount of power lost in resistance, high-power charges are more affected by internal resistance. Therefore, rapid charging processes will be more energy inefficient than leisurely ones. So, batteries need to be able to handle the increased heat during charging that comes from the internal resistance. Additionally, if this resistance could be lowered, the time required for charging, a major restriction for electric cars, may be reduced.

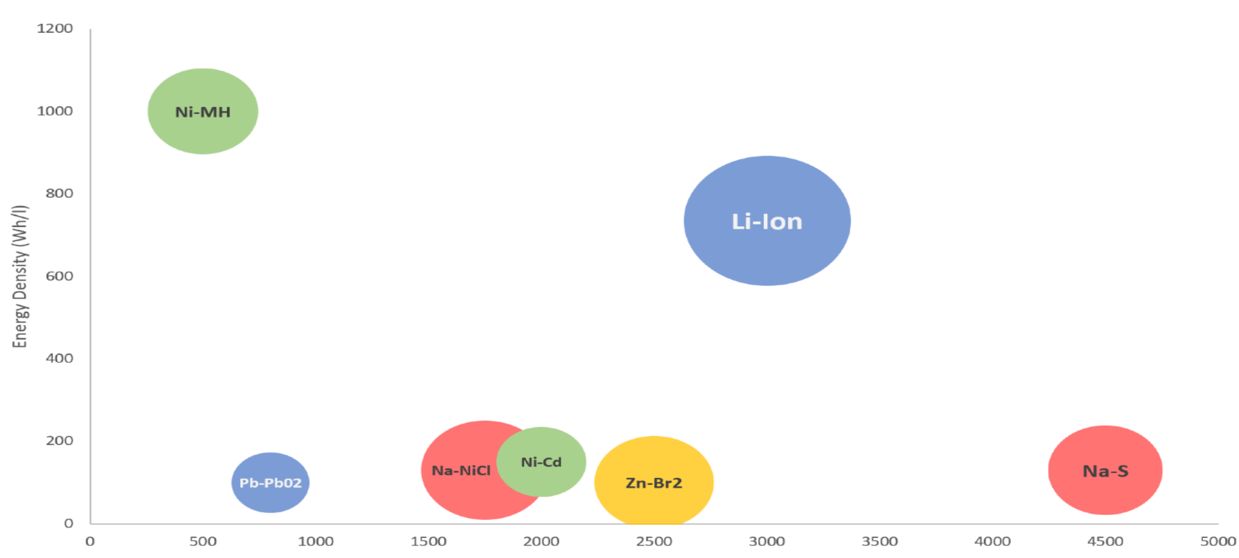

Fig: The x-axis represents cycle life, while the y-axis represents energy density. The x-axis represents specific energy, and the y-axis represents working temperature (bubble colour). Keep in mind that the warmer the colour, the hotter the environment.

The costliest component of any electric vehicle is its battery pack. As an example, the original purchase price of a Nissan LEAF was largely determined by the price of its lithium-ion batteries. Battery packs now cost $1,000 per kilowatt-hour (kWh), although that number is expected to drop to $500 by the end of 2013. The current cost per kilowatt-hour is $200, but projections show that it will drop to $100 by 2025. The fact that Tesla Motors is building a

"Gigafactory" to streamline battery manufacturing and bring down production costs is another piece of evidence that battery prices are trending downwards. At the Gigafactory, they'll be cranking out more lithium-ion batteries.

When compared to Ni-MH and Li-ion batteries, lead and zinc batteries have the lowest specific power (up to 100 W/kg), while Ni-Cd and Ni-MH batteries have the most (up to 1000 W/kg and 3000 W/kg, respectively). When compared to other battery types, nickel and zinc batteries have a lower voltage, while lithium-ion and sodium batteries need a greater voltage (Na-S and Na-NiCl). NiMH and lithium-ion batteries, in contrast to lead-acid batteries, have the worst life-cycle performance. Finally, lithium batteries can only withstand up to 3000 cycles before they die, but Na-S batteries can withstand up to 4500 cycles.

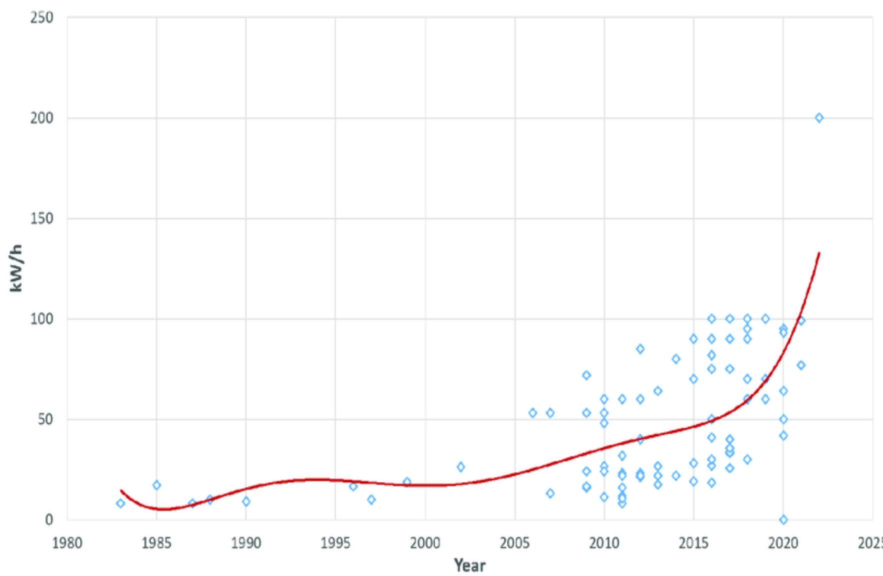

Fig: Changes in battery capacity beginning in the mid-1980s and continuing to the present

The next graph shows how EV battery capacity has grown from 1983, when the Audi Duo came out with an 8-kWh battery, to 2022, when Tesla says it will sell a Tesla Roadster with a 200-kWh battery. The autonomy of an EV is crucial when traveling, but the amount of time needed to charge the batteries is also a limiting element. The typical power outlets have a 3-kW power rating, which means that a battery may be charged to a maximum of 30 kWh of energy with a 10 h load on average. Even when employing quick charging systems, it may still take between one and three hours to fully charge a vehicle.

Table: Battery capacities of different EVs

Vehicle	Year	Capacity (KWh)
Audio duo	1983	8
Skoda Favorit	1988	10
Tesla Roadster	2006	53
Smart ed	2007	13.2
Tesla Roadster	2007	53
Nissan Leaf	2009	24
BYD e6	2010	48
Tata Indica Vista EV	2010	26.5
Tesla Roadster	2010	53
BMW ActiveE	2011	32
BMW i3	2011	16
Ford Focus Electric	2011	23
BYD e6	2011	60
Tesla Model S	2012	40,60,85
Ford Focus Electric	2012	23
BYD e6	2012	64

Smart ed	2013	17.6
Volkswagen e-Golf	2013	26.5
Renault Fluence Z.E	2014	22
Tesla Roadster	2014	80
Mercedes Clase B ED	2015	28
Tesla Model S	2015	70,90
BYD e6	2016	82
Kia Soul EV	2016	27
Nissan Leaf	2016	30
Renault Zoe	2016	41
Tesla Model 3	2016	50,75
Tesla Model X	2016	90,100
BMW i3	2017	33
Ford Focus Electric	2017	33.5
Honda Clarity EV	2017	25.5
Jaguar I-Pace	2017	90
Tesla Model 3	2018	70,90
Kia Soul EV	2018	30
Nissan Leaf	2018	60
Mercedes-Benz EQ	2019	70
Volvo 40 series	2019	100
Audi e-tron	2020	95
BMW i3	2020	42
Hyundai Kona e	2020	64
Peugeot e-208	2020	93
Ford Mustang Mach-E	2021	99
V0lkswagen ID.3	2021	77
Tesla Roadster	2022	200

Charging of electrical vehicles:

The duration and conditions of the battery-charging process are just as important as the vehicle's autonomy. Without a shadow of a doubt, the success of electric cars depends on the convenience and speed with which their owners can charge their vehicles. To do this, it will be necessary for Smart Cities 2021 (4386) to implement an infrastructure rollout that allows for such fast and simple charging. This hints to the need for both home charging and the establishment of fast-charging electric charging stations for extended journeys. See below for an illustration of the many standards and criteria that have been established for the charging technology utilized by EVs. We pay special attention to the connections and the different ways of charging that the standards define.

Table: Charging ratings of the SAE-J1772

Charge Method	**Volts**	**Maximum Current (Amps-Continuous)**	**Maximum Power**
AC Level 1	120V AC	16A	1.92KW
AC Level 2	240V AC	80A	19.2KW
DC Level1	200 to 500 V DC maximum	80A	40KW
DC Level2	200 to 500 V DC maximum	200A	100KW

• AC Level 1: Standard electrical outlet with a maximum power output of 1.9 kilowatts and an AC voltage of 120 volts, providing a maximum current of 16 amperes.

• AC Level 2, a standard electrical socket that can provide up to 19.2 kW of electricity through 240 V AC at 80 A.

• DC Level 1: An external charger that accepts up to 500 V DC and 80 A of current and puts out 40 kW of power.

• DC Level 2: two-cycle direct current (DC) Level 2. a high-output external charger that can provide 100 kW by delivering 500 V DC at 200 A.

Multiple pricing methods:

In 2001, The IEC-62196 standard for charging electric vehicles is a product of the International Electrotechnical Commission (IEC). Standard IEC-62196 explains how the charging process works as a way to send power. This standard is based on IEC-61851, and the nominal power is used to first categorize the charging type and, by extension, the billing cycle. The four possible charge methods are as follows:

• Mode 1 (slow charging). It's a kind of home charging that utilizes a conventional single- or three-phase power outlet with phase(s), neutral, and protecting earth wires and has a maximum current of 16 A. In our families, we mostly used this style of communication.

• Mode 2 (semi-fast charging) As with the preceding mode, conventional power outlets consisting of phase(s), neutral, and protecting earth wires are used. This mode may be employed in either a domestic or public setting, and its specified maximum intensity is 32 A.

• Mode 3 (fast charging) It offers a range of brightness, from 32 to 250 A. To utilize this charging method, an EV Supply Equipment (EVSE)—a dedicated source of electricity for recharging EVs—must be connected to the car. The electric vehicle supply equipment (EVSE) lets the cars talk back and forth with the charging station, keeps track of the charging process, has safety features, and cuts power if it thinks the connection has been lost.

• Mode 4 (ultra-fast charging) With the IEC-62196-3 standard in place, a direct connection may be made between the electric vehicle and the DC supply network, with a maximum voltage of 1000 V and a maximum current of 400 A, for a maximum charging power of up to 400 kW. For these charging modes to work, you need a dedicated external charger that can talk back and forth between the car and the charging station and has security and management features.

Charge Method	**Phase**	**Maximum Current**	**Voltage (max)**	**Maximum Power**	**Specific Connector**
Mode 1	AC Single AC Three	16A	230-240 V 480V	3.8KW 7.6KW	No
Mode 2	AC Single AC Three	32A	230-240V 480V	7.6KW 15.3KW	No
Mode 3	AC Single AC Three	32-250A	230-240V 480V	60KW 120KW	Yes
Mode 4	DC	250-400A	600-1000V	400KW	Yes

4.Results and Discussions:

The transition to electric vehicles as the standard on our roads and in our communities faces a variety of obstacles. Recent improvements in EV range, power, technology, and comfort are definitely making people more likely to give EVs serious thought when they need a new car. The price may be somewhat higher (especially when compared to the combustion engine version of the vehicle), but the gap is being narrowed through purchasing incentives and reduced tax rates. There are other variables that, although crucial, nevertheless need to be addressed in order to pave the way for electric automobiles. The widespread availability of EV charging stations is the one of these major factors. Undoubtedly, sales have been hampered by the general absence of charging infrastructure in most nations until this point. We think greater effort should be made to improve the charging infrastructure. In order to make electric cars more attractive to consumers, the time required to completely charge their batteries must be drastically reduced. We're glad that we think the combination of AI and vehicle communications will speed up the spread of cleaner, more efficient ways to get around.

We'll be talking about charging in this section since it's crucial to electric cars' ability to go further than they might otherwise without a battery, and hence is an important part of any battery-powered vehicle. The connection is one of the most important parts of the charging process for an electric car. Connections recommended by the IEC-62196 standard are used in European automobiles, whereas connectors proposed by the J1772 standard are used in vehicles sold in the United States and Japan. Even though these markets are very different and have nothing to do with each other, the fact that consumers might need to buy adapters, which could raise the price of electric vehicles and sometimes cause safety problems, is not good.

Since wireless charging may be used to refuel EV batteries while the vehicle is in motion, it deserves serious attention as an alternative to wired charging. The convenience and adaptability of wireless power transfer (WPT) make it a useful technology. There are two methods of wireless charging: capacitive power transfer (CPT) and inductive power transfer (IPT) (IPT). In conclusion, IPT is the most often used method since it can be performed with a variety of gap widths and power levels. Even though CPT has been shown to work for applications that need kilowatts of power, it can only be used for small-gap power transfers.

5.Conclusion:

This article looks at the many types of EVs, the technology they use, the advantages they have over conventional cars, sales trends over the last several years, how they are charged, and what the future may hold for this industry. We also discussed the main research obstacles and untapped potential. The range of an electric vehicle is directly proportional to its battery life. Considering these factors, we investigated many battery options. We also spoke about some promising future technologies, such as graphene, which has the potential to allow for more efficient charging and a larger capacity for energy storage. This technique might increase the EV's range, making it more appealing to potential buyers. Larger battery capacities will require the use of faster, more powerful charging technologies, as well as more sophisticated wireless charging systems. Another thing that could help electric cars spread is the creation of a universal connection. Future Smart Cities will have a significant impact on the EV industry, so it will be especially crucial to have flexible charging techniques that can respond to consumer needs. Future BMS should therefore take into account new battery technologies and Smart City requirements have created new possibilities.

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