Electric Vehicle Technology Opportunities and Challenges

[1]B. Sachuthananthan, [2]N. Padmaja, [3]Fardeen Shaik, [4]P. Sunil kumar, [5]M. Gowtham Vyas, [6]N. K. Miller Jothi
[1,2,3,4,5] *Mechanical Engineering, Sree Vidyanikethan Engineering College,* Tirupati, India.
[6]*Mechanical Engineering, Sri Eshwar College of Engineering*, Coimbatore, India.
[1]sachuthananthan.b@vidyanikethan.edu, [2]padmaja.n@vidyanikethan.edu, [3]fardeenshaik549@gmail.com,
[4]pittisunilkumar3@gmail.com, [5]gowtham.malkari24@gmail.com, [6]millerjothi.nk@sece.ac.in

2024 10th International Conference on Advanced Computing and Communication Systems (ICACCS) | 979-8-3503-8436-9/24/$31.00 ©2024 IEEE | DOI: 10.1109/ICACCS60874.2024.10717213

***Abstract*— Electric cars (EVs) are growing in popularity for a number of reasons, including lower costs as well as more ecological and environmental concern. This article looks at advancements in electric vehicle technology, including charging methods, battery advancements in technology, and also fresh research difficulties and untapped prospects. Most precisely, a review of the present and future potential of the global EVs market is made. Because the battery is a critical component of EVs, the lead-acid to lithium-ion(Pb-Li) battery systems are all examined in this article. The various EV charging protocols that are available are also examined, along with ideas for battery and power control management. Finally, we conclude this work by outlining our expectations for this field's future and reviewing the research topics that are available to both educational and business entities.**

Keywords—Hybrid Electric Vehicles, Electric Vehicles (EVs) , Battery Storage Technology, Charging Modes.

I.INTRODUCTION

Both financially and in terms of R&D, the automobile industry has developed into one of the primary key sector worldwide. Vehicles are becoming more common. using technical aspects to increase safety from accidents. In addition, more vehicles are on the road, allowing us to move swiftly and comfortably. Regrettably, the number of air pollutants in metropolitan areas has increased significantly, including emissions such as nitrogen oxides (NOx), carbon monoxide (CO),Sulphur dioxide (SO2), and particulate matter (PM) .Furthermore, a research by the European Union found that the transportation sector is accountable for about 28% of global CO2 emissions, with travel accounting for more than 70% of these emissions. To reduce the number of pollutants in the atmosphere, the majority of developed countries promote the usage of electric vehicles. [2]More precisely, EVs promote efficient and sustainable mobility through a number of programs, notably through tax benefits, financial support, or another measures such as free landfill access parking in the public or highway. [3] There are certain characteristics of an electric vehicle such as their driving range, charging time and cost which makes them less convenient in today's world. EVs are more expensive than conventional engine vehicles (Coffman et al., 2017). Carley et al. (2013) found that the cost of the EVs is more dominant as compared to another traditional vehicle. Graham-Rowe et al. (2012) also concluded that people were not willing to pay the high cost as demanded by EVs. [4]Here are the benefits of electric vehicles:Zero emissions: EVs do not have Carbon dioxide or nitrogen dioxide emissions. Even though the manufacturing techniques of the battery are ecofriendly but its production has a negative influence on the carbon footprint. [5].

Simplicity: As there are very few EV engine components, maintenance is substantially less expensive. The engines are more small and more compact; they don't need a cooling system, a clutch, a shifter, or any components that lessen engine noise. [6]Reliability: This kind of vehicle is more dependable since it has fewer, easier-to-maintain components. Furthermore, vibrations, engine explosions, or fuel corrosion do not create wear and tear.Cost: The cost of maintaining the car is significantly less. when compared to the fuel expenses and maintenance of conventional combustion cars. [7]Comfort: Driving an EV is more comfortable because there are no engine vibrations or sounds.[8]In terms of fuel efficiency, EVs surpass the performance of regular cars. Well to Wheel (WTW) efficiency will be influenced by the power plant's efficiency. The total WTW efficiency of gasolin vehicles ranges from 11% to 27%, whereas that of diesel vehicles ranges from 25% to 37%. [9]Accessibility: This kind of vehicle makes it possible to travel in urban areas where many combustion vehicles are not allowed. Large cities do not have the same driving restrictions as smaller towns, especially during periods of severe contamination. [10]

II.ELECTRIFIED VEHICLES:

We classify the many types of electric vehicles in this category and remark on their major characteristics. In addition, we examine sales information for this type of autos as well as worldwide sales estimates to assess the current status of the sector.Several different types of EVs are now available. They are usually classified into five types.

A. Battery Electric Vehicles (BEVs):

These automobiles are electric-only machines. BEVs do not use fuel and do not have an IC engine. BEVs frequently use massive battery cells to provide the vehicle with a comfortable amount of autonomy. Although some BEVs have a single-charge range of up to 500 km, the average BEV has a range of 160–250 km. This class of vehicle consists of the Nissan Leaf [11], a fully electric vehicle with a 62-kWh battery that currently offers buyers 360 km of autonomy.

PHEVs (plug-in hybrid electric vehicles) are hybrid vehicles featuring an electric motor powered by an externally plugged-in power source in addition to a conventional combustion engine.[12] PHEVs can store enough grid power to significantly lower their petrol consumption under typical driving conditions. The

979-8-3503-8436-9/24/$31.00©2024 IEEE

Mitsubishi Outlander PHEV [13] can go about 50 kilometers with only its electric powertrain thanks to its 12 kWh battery.[14] It's important to keep in mind that PHEVs use more gasoline than automakers anticipate.

B. Hybrid Electric Vehicles (HEVs):

Hybrid vehicles generate power by combining an IC engine and an electric motor. HEVs differ from PHEVs in that they are not connected to the grid. The battery that drives the electrical motor is charged using the power generated by the combustion engine of the HEV. Braking power can also be utilized to recharge batteries in more modern cars, converting kinetic energy to electric energy. With a 1.3 kWh battery, the hybrid fourth-generation Toyota Prius had an all-electric driving range of up to 25 kilometers.

C. Fuel cell electric vehicles (FCEVs):

employ an electric engine that burns compressed hydrogen and oxygen from the air, with water as the only byproduct. Although these vehicles are said to have "zero emissions," it is important to emphasize that green hydrogen also exists and that the great majority of hydrogen that is consumed is produced from natural gas. One kind of car is the Hyundai Nexo FCEV, which has a 650-kilometer estimated range.

D. Extended-range electric vehicles (ER-EVs):

These vehicles resemble BEVs in terms of design. The ER-EVs also have a backup combustion engine that may be used to recharge the vehicle's batteries if necessary. Unlike PHEVs and HEVs, this engine is not connected to the wheels and is just utilized for charging. For instance, the BMW i3 has a 42.2 kWh battery that offers 260 km of pure electric autonomy and an additional extended range of up to 130 km.

E. Subsidies and Market Position:

Even though the price of an EV is higher than the price of a similar model with an internal combustion engine, in recent years, EV sales have increased significantly. Also, a number of governments are preparing for the switch to electric mobility by outlawing the use of gasoline-powered vehicles. This has been seen by the rise in government subsidies for these vehicles after the Paris Accord.

Governments in developed nations are continually enacting new regulations to promote the use of electric vehicles in an effort to promote environmentally friendly and sustainable transportation.

Despite the fact that a few of countries have declared an intention to ban combustion engine automobiles in future, [42-48] expect that these numbers will continue to climb in future. For instance, Norway recently declared that all vehicles sold starting in 2025 may have zero emissions. Israel, Netherlands and the India, on the other hand, have said that by 2030, all automobiles sold would be electric. The United Kingdom, California and Germany have agreed to postpone the deadline until 2040.

Apart from the optimistic global sales forecast, it is worth mentioning that 95% of electric vehicles were sold in only 10 nations (China, the United States, Canada, Japan, the United Kingdom, Norway, the United Kingdom, Germany, France, Sweden and the Netherlands).

It should also be mentioned that there are presently several BEV and PHEV vehicles for sale. The Tesla Model 3 (BEV), Toyota Prius Prime (PHEV), Nissan Leaf (BEV), Tesla Model S (BEV), Chevrolet Volt, BMW i3 (BEV) [30,49], and Ford Fusion Energy are among the most popular models (PHEV).

F. Batteries:

This section describes the fundamental properties, cost savings, and intriguing facts about batteries, as well as information on the various technologies now employed in the production process. In recent years, Battery technology has advanced significantly. Furthermore, global manufacture of EV batteries has surged by 66%, which is undoubtedly related to the increase in vehicle sales and the anticipated need for batteries. Furthermore, both production and demand for EVs are expected to rise dramatically in the coming years.

The time and characteristics of the battery charging operation, are critical. For electric vehicles to thrive, consumers need to be able to recharge their vehicles fast and conveniently. It's vital to provide an infrastructure that enables such quick and easy charging. This needs the installation of fast-charging electric charging stations for long-distance travel in addition to home charging. The several standards or guidelines established for the technology needed to charge electric vehicles are listed below. We focus on the connections used by modern standards and the various charging alternatives.

G. Connectors:

Electric car batteries may be recharged at home using ordinary outlets, thanks to an AC/DC converter (e.g., the Schuko plugs in Europe). however, electric vehicle charging stations when a faster charge is needed, stations must be used as they can provide DC power to the batteries. Depending on the recognised standards, charging stations can deliver power via a variety of connectors and offer the following advantages:

- The items are sealed (not affected by humidity or water).
- They have an electrical or mechanical impediment.
- These allow you to communicate with the automobile.
- Electricity is not provided till the blocking mechanism is turned off.
- A car cannot move when plugged in because the blocking mechanism stops it from starting.
- Some connectors support three-phase charging.

Currently, a variety of connectors are available for charging electric vehicles. In the US and some Pacific Island countries, the Society of Automotive Engineers (SAE) is in charge of standardizing these connectors; in a significant portion of the world, primarily in Europe, that responsibility falls to the International Electrotechnical

Commission (IEC); and in China, that responsibility falls to Guobiao Standards (GB).

The suggested structure's operational foundation is: The micro turbine propels the permanent magnet synchronous machine (PMSM) at high speeds, generally 96,000 rpm, and produces a high frequency fluctuation of 1500 - 4000 Hz. The high frequency alternating current voltage is then adjusted. The one-way DC/DC converter manages the output power generated by the microturbine and sent to the electric vehicle's battery. Before the MGT develops its operational the supercapacitor supplies the required energy. In accordance with the electric vehicle's battery charge cycle, the supercapacitor is charged so that it will be prepared for the system's next start. Due to the fact that supercapacitors are frequently made up of stacks with voltages that are significantly lower than J1772-2009 connections feature multiple layers of protection and can be used in wet environments. The AC version, which has five pins and was developed for single-phase electric systems with 120 V or 240 V.

- The AC pins used to power the vehicle, including the phase and neutral pins.
- As a safety precaution, a ground connection connects the electrical system to the earth.
- Proximity detection, which forbids moving plugged-in cars
- The vehicle's Pilot Control, which allows communication.

III. POWER CONTROL AND ENERGY MANAGEMENT

An essential feature of EVs and PHEVs is energy management. To track and control the battery unit in this kind of vehicle, the battery management system (BMS) was developed. In order to ensure the safety and dependability of the batteries, the battery management system (BMS) is in charge of managing the energy they supply. A power supply unit, sensors, and communication routes are all integrated components of modern BMSs. BMSs' major job is to regulate power supply while attempting to minimize battery wear from charges and discharges. The BMS serves as the primary controller, reducing unexpected current swings and lowering output rates.

Because a lengthy string of single cells is only as dependable as its weak point, cell balancing is essential for the high-powered battery seen in EVs. The BMS ensures cell balance by adjusting for the strain of the weak cell. It particularly equalizes the charge throughout every chain's cells to increase the battery pack's overall lifespan. BMS prevents overstressing certain cells in this way.

BMSs also carry out essential tasks including determining the driving range and evaluating the charge state. The battery pack also supplies electricity to auxiliary parts including the dashboard, cooling/heating system, and headlights. These devices, however, lack intelligence and BMS communication.

Numerous BMS designs have been proposed by different authors in response to all of the issues mentioned. A BMS must be able to handle the following duties, according to Hauser and Kuhn [87]: data gathering, processing, and storage, as well as management of safety, temperature, electricity, and communication. They provide a BMS schematic drawing that takes into account all of these characteristics. Several publications give an overview of BMS for BEVs and HVs, with the status of charge, health, and life as the important components to be handled by BMSs (HVs).

A. Challenges of the Research and Open Opportunities:

While great progress has been made in the evolution and development of electric vehicles, especially over the past few years, this section discusses challenges that are still being worked on or may be worth researching in order to propose new and better solutions. These possibilities can be classified into four categories: I, new battery technologies or manufacturing methods; II, optimizing and improving the charging process; III, utilizing communication systems and artificial intelligence in electric vehicles to improve mobility and make better use of the infrastructure for charging; and IV, eco-friendly technology charging (i.e., using green energy) and EV sustainability concerns.

B. Improvements in the Charging Process:

This section focuses on the charging process, which is an essential element of battery-powered vehicles and is especially crucial for Ev’s since it allows them to go further.

While charging an electric vehicle, one of the most important elements to consider is the connection. Although European autos use the connections specified by the IEC-62196 standard, the J1772 connections are used in Japanese and American markets. Despite these markets are highly unique and separate from one another, this aspect is undesired since it may make it difficult for consumers to charge their cars; It might be essential to purchase adapters, raising the price of EVs and occasionally raising safety issues. This issue affects rapid charging stations. There are now three types of connections for carrying out quick charges, as previously stated in this section: I. include the CHAdeMO in IEC-62196,II. include the CCS in J1772, and III. include the GB/T. We should also take into account the one employed by Tesla in its superchargers.

We feel it is more important to progress the development of a single standard that would allow charging all automobiles through a common connector, despite the fact that companies like Tesla, for example, have bet on the fact that some of their vehicles have more than one type of connection.

C. Communications and AI in Electric Vehicles:

A number of previously earlier difficulties will need to be addressed before electric cars can entirely replace traditional modes of transportation as the mainstay on our roads and in our communities.

Recent developments in autonomy, power, technology, and comfort, it goes without saying, are urging buyers to carefully consider EVs when shopping for a new automobile. While the price is marginally greater (the difference between the combustion engine is visible in certain models), purchase discounts and lower tax rates are also helping to decrease the current price gap.

Until now, the scarcity of charging infrastructure in the majority of countries has likely prevented purchases. We feel that greater effort should be made into improving charging infrastructure. To make electric vehicles more appealing to buyers, the time required to completely charge their batteries must be greatly reduced. Fortunately, we believe utilizing AI and automobile communications will aid in the successful adoption of new, more ecofriendly, and sustainable modes of transportation.

IV. CONCLUSIONS

This article studied the many types of Electric Vehicles, the technology used, the advantages over IC engine automobiles, evolution of sales in the previous several years, together with numerous charging techniques and prospective future innovations. We also spoke about the major research challenges and untapped possibilities.

Since they have an impact on the autonomy of the vehicle, batteries are important for EVs. In light of these characteristics, we looked into a number of battery types. We also talked about prospective future technologies, such as graphene, which is probably going to be used to store more electricity and enable quicker charging. The development of the EV might also benefit from this kind of technology.

More stronger charging methods and more advanced wireless charging systems, will be encouraged by larger storage batteries. The creation of a universal connection is another aspect that can influence the adoption of electric vehicles. Future Smart Cities will have a huge influence on the EV market, therefore having flexible charging procedures that can adjust to customer needs will be extremely important. Future BMS should thus include the new situations brought about by new batteries as well as the demands of Smart Cities.

REFERENCES

[1] J. Guo, “Research on simplified SVPWM strategy for nine-switch converter,” Journal of Power Electronics, vol. 20, no. 6, pp. 1386–1394, Aug. 2020, doi: 10.1007/s43236-020-00124-5.

[2] Cristina Arranz, “Determining the Number of Ants in Ant Colony Optimization”, Journal of Biomedical and Sustainable Healthcare Applications, vol.3, no.1, pp. 076-086, January 2023. doi: 10.53759/0088/JBSHA202303008.

[3] Morgan Ericsson and Tina Persson, “A Review of Business Intelligence and Analytics in Small and MediumsizedEnterprises”, Journal of Enterprise and Business Intelligence, vol.2, no.2, pp. 077-088, April 2022. doi: 10.53759/5181/JEBI202202009

[4] Vita Kogan and Morley Maria, “A Development and Implementation of Manufacturing Resource Planning System for Small and Medium Enterprises”, Journal of Enterprise and Business Intelligence, vol.2, no.2, pp. 056-065, April 2022. doi: 10.53759/5181/JEBI202202007.

[5] K. Suresh and E. Parimalasundar, “A Modified Multi Level Inverter With Inverted SPWM Control,” IEEE Canadian Journal of Electrical and Computer Engineering, vol. 45, no. 2, pp. 99–104, 2022, doi: 10.1109/icjece.2022.3150367.

[6] Judith Zilberman, “An Analysis of Evolutionary Methodology for Interpretable Logical Fuzzy Rule-Based Systems”, Journal of Biomedical and Sustainable Healthcare Applications, vol.3, no.1, pp. 066-075, January 2023. doi: 10.53759/0088/JBSHA202303007.

[7] J. Liu, W. Lin, J. Wu, and J. Zeng, “A Novel Nine-Level Quadruple Boost Inverter With Inductive-Load Ability,” IEEE Transactions on Power Electronics, vol. 34, no. 5, pp. 4014–4018, May 2019, doi: 10.1109/tpel.2018.2873188.

[8] P. Ezhilvannan and S. Krishnan, “An Efficient Asymmetric Direct Current (DC) Source Configured Switched Capacitor Multi-level Inverter,” Journal Européen des Systèmes Automatisés, vol. 53, no. 6, pp. 853–859, Dec. 2020, doi: 10.18280/jesa.530611.

[9] M. Chen, Y. Yang, P. C. Loh, and F. Blaabjerg, “A Single-Source Nine-Level Boost Inverter With a Low Switch Count,” IEEE Transactions on Industrial Electronics, vol. 69, no. 3, pp. 2644–2658, Mar. 2022, doi: 10.1109/tie.2021.3065609.

[10] Bader Andersson, “An Assessment of the Effects of Enterprise Resource Planning Adoption in SMEs”, Journal of Enterprise and Business Intelligence, vol.2, no.2, pp. 066-076, April 2022. doi: 10.53759/5181/JEBI202202008.

[11] J. Zhao, Y. Chen, J. Zeng, and J. Liu, “A Hybrid Nine-Level Inverter With Reduced Components and Simplified Control,” IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 10, no. 4, pp. 4498–4508, Aug. 2022, doi: 10.1109/jestpe.2022.3152994.

[12] K. Suresh and P. E., “Design and Implementation of Universal Converter Conception et implémentation d’un convertisseur universel,” IEEE Canadian Journal of Electrical and Computer Engineering, vol. 45, no. 3, pp. 272–278, 2022, doi: 10.1109/icjece.2022.3166240.

[13] N. Eashwaramma and J. Praveen, “Modelling and simulation of a multilevel inverter using space vector modulation technique to mitigate for power quality problems,” International Conference on Recent Trends in Engineering, Science & Technology - (ICRTEST 2016), 2016, doi: 10.1049/cp.2016.1481.

[14] Parimalasundar, N. M. G. Kumar, P. Geetha, and K. Suresh, “Performance investigation of modular multilevel inverter topologies for photovoltaic applications with minimal switches,” Electrical Engineering & Electromechanics, no. 6, pp. 28–34, Nov. 2022, doi: 10.20998/2074-272x.2022.6.05.

[15] Dinesh Kumar K and Duraimutharasan N, “Two Fish Encryption Based Blockchain Technology for Secured Data Storage, Journal of Machine and Computing, vol.3, no.3, pp. 216-226, July 2023. doi: 10.53759/7669/jmc202303020.

[16] Liu, X. Zhang, L. Pan, and A. Li, “Modelling and Control of Nine-Switch Converter-Based DFIG Wind Power System,” Journal of Electrical Engineering & Technology, vol. 15, no. 6, pp. 2587–2599, Aug. 2020, doi: 10.1007/s42835-020-00506-6.