Chapter 3

Electric Vehicles: Technological, Energetic And Environmental Dimensions

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Abstract

Electric vehicles represent a major technological shift in the transportation sector, driven by advancements in electrification and energy systems. This book chapter provides a structured and comprehensive overview of electric vehicles with a primary focus on their technological and energetic dimensions. The chapter begins by outlining the historical development of electric vehicles, followed by a detailed classification of vehicle types, including battery electric vehicles, hybrid electric vehicles, and fuel cell electric vehicles. The fundamental technical components of electric vehicles are subsequently examined, emphasizing electric motors, power electronics systems, and energy management strategies. Energy storage systems are discussed in detail, covering battery technologies currently used in electric vehicles, battery management systems, and emerging battery technologies that may contribute to improved performance, reliability, and system integration. Finally, future-oriented technological trends are explored with respect to ongoing developments in electrified powertrains, energy storage solutions, and system-level integration. Overall, this chapter aims to present an academically rigorous and up-to-date reference that supports a deeper understanding of electric vehicle technologies and their technological evolution.

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1. Introduction

The increasing global population, rising urbanisation rates and increased demand for individual transport are causing a significant rise in energy consumption [1]. A major portion of this increase is attributable to the transport sector. Road transport, in particular, plays a decisive role in terms of fossil fuel consumption and associated greenhouse gas emissions. Issues such as climate change, air pollution and energy supply security have made it imperative to develop more sustainable solutions in vehicle Technologies [2]. Research into reducing environmental pollutants highlights the need for sustainable approaches and emphasises the strategic importance of clean energy Technologies [3], [4], [5].

Electric vehicles are considered one of the key components of this transformation due to their high energy efficiency drive systems, low operating costs, and near-zero emissions at the local level. The structural simplicity offered by electric propulsion systems, along with advantages such as reduced mechanical losses and enhanced driving comfort, have led to these vehicles being extensively studied in both academic and industrial circles [6].

This chapter examines electric vehicle technologies in detail from an academic perspective, covering their historical development, classification approaches, fundamental technical components, energy storage systems, charging infrastructure, environmental and economic impacts, and future trends. The aim is to present the role of electric vehicles within transport systems in a comprehensive framework.

2. The Historical Development of Electric Vehicles

The origins of electric vehicles date back to a similar time period as internal combustion engine vehicles. The first electric vehicles, developed in the late nineteenth century, were considered a noteworthy alternative for urban transport at the time due to their quiet operation and ease of use. However, the limited energy density of battery technology and long charging times prevented these vehicles from becoming widespread.

The historical development of electric vehicles dates back to the early nineteenth century. In 1800, Alessandro Volta demonstrated that electrical energy could be stored through chemical means, laying the foundation for electrochemical energy storage systems. Subsequently, in 1821, Michael Faraday conducted experiments based on Volta's chemical cell, leading to the fundamental principles of electric motors and generators. The first known electric vehicle model was constructed in 1835 in the Netherlands by Professor Stratingh. During the mid-1830s, electric road vehicles were also developed in the United States by Thomas Davenport, followed by the introduction of an electric locomotive by Robert Davidson, both of which relied on non-rechargeable batteries. The advancement of rechargeable lead–acid batteries after 1859 marked a significant milestone in electric vehicle technology. By the late nineteenth century, electric vehicles equipped with lead–acid batteries began to emerge, including early three-wheeled designs demonstrated in Europe. In the 1880s, several practical electric vehicles were developed in France and the United Kingdom, achieving modest driving ranges and speeds suitable for urban transportation. Towards the end of the nineteenth century, electric vehicle production expanded in the United States and Europe, with notable contributions from companies such as the Electric Carriage and Wagon Company. At the beginning of the twentieth century, electric vehicles were widely adopted in the United States, even outnumbering gasoline-powered vehicles at certain points. However, improvements in intercity road networks and increasing demand for longer driving ranges during the 1920s gradually reduced the competitiveness of electric vehicles, leading to a decline in their widespread use [7]. Figure 1 shows an example of one of the electric vehicles.

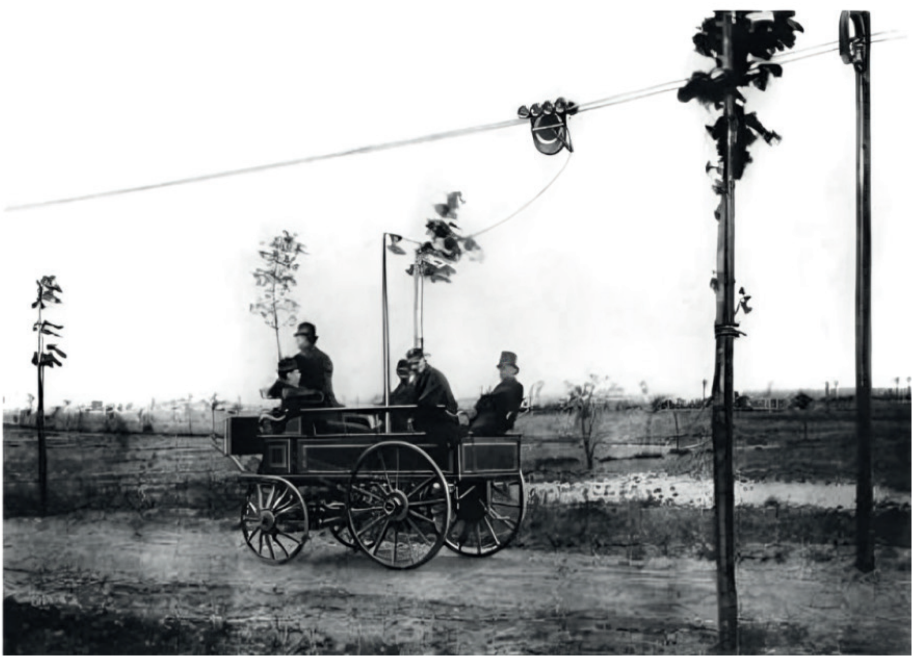

Figure 1. One of the first examples of an electric vehicle [8]

The first mass-produced electric vehicle, the EV1, was manufactured in the United States by General Motors in 1996. With this development, the automotive industry shifted its focus back towards electric vehicles. Various brands and models were launched, including the Honda EV Plus, Toyota RAV EV, Ford-Think City, Nissan Altra EV, and Peugeot 106 Electric [9].

The rapid development of internal combustion engine technologies in the first half of the 20th century, the availability of cheap oil resources, and the widespread adoption of mass production techniques led to electric vehicles being relegated to the background. However, the oil crises of the 1970s brought the issue of energy supply security back to the forefront and accelerated research into alternative propulsion systems. Since the 1990s, stricter environmental regulations, concerns about urban air quality and advances in battery technology have brought electric vehicles back into the spotlight. In particular, the commercial viability of lithium-ion batteries is considered a turning point in the development of modern electric vehicles [10].

3. Types and Classification of Electric Vehicles

Electric vehicles are examined under different categories based on their energy source and drive system architectures. This classification is important for understanding the usage scenarios and environmental impacts of the vehicles. Electric vehicle technologies are categorised under three main models: fully electric vehicles, hybrid electric vehicles, and battery or non-battery fuel cell vehicles [10]. Figure 2 shows the classification of electric vehicles according to their types.

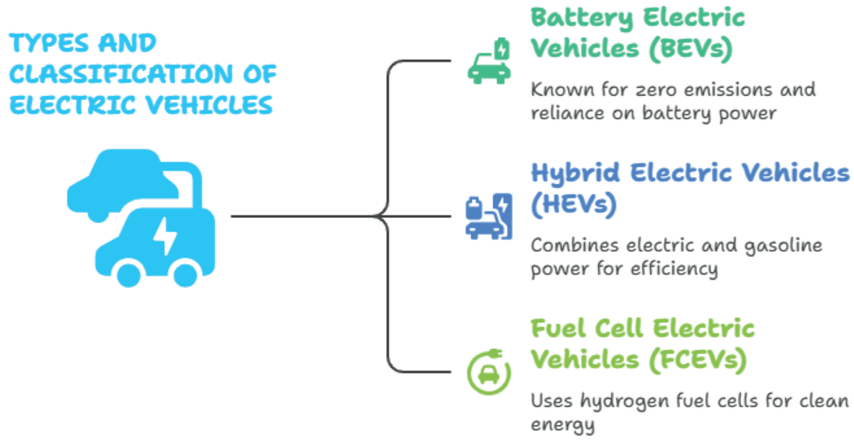

Figure 2. Classification of electric vehicles

3.1. Battery Electric Vehicles (BEV)

Battery-powered electric vehicles are vehicle systems that derive all their propulsion energy from electrical energy stored in battery packs. These vehicles do not contain internal combustion engines; kinetic energy is generated solely through electric motors. The high efficiency of electric motors and the energy recovery provided by regenerative braking systems contribute significantly to reducing overall energy consumption. The BEV architecture reduces maintenance requirements due to its mechanically simpler structure. However, limited range and dependence on charging infrastructure are among the main factors limiting the widespread use of these vehicles. The key features of BEVs include a fully electric drive system, typically high-capacity lithium-ion-based battery packs, high motor efficiency, and regenerative braking capability. The absence of an internal combustion engine eliminates exhaust emissions, contributing to improved air quality and reduced greenhouse gas emissions. The main advantages of battery-powered electric vehicles include zero exhaust emissions, low energy costs, reduced maintenance requirements, and quiet operation. Furthermore, tax reductions and incentive mechanisms implemented in many countries increase the economic appeal of BEVs. However, range limitations dependent on battery capacity, relatively long charging times, battery life, and battery replacement costs are considered fundamental constraints of these vehicles. Additionally, environmental benefits may vary depending on the structure of the energy sources used in electricity production [11].

3.2. Hybrid Electric Vehicles (HEV)

In hybrid electric vehicles, the internal combustion engine and electric motor work together to meet the vehicle's propulsion needs. The electric motor typically engages at low speeds and in stop-start conditions, contributing to reduced fuel consumption and emissions. Due to the limited capacity of the battery, energy is mostly supplied through regenerative braking or via the internal combustion engine. Plug-in hybrid electric vehicles (PHEVs) feature higher-capacity batteries that can be charged from an external power source. This allows short journeys to be completed in fully electric mode, while the internal combustion engine kicks in for longer distances, reducing range anxiety [12].

Hybrid electric vehicles (HEVs) are defined as vehicles that utilise multiple energy storage and conversion systems simultaneously. In the literature, hybrid vehicles are primarily classified based on their propulsion architecture, degree of hybridisation, and the nature of the energy source used. In terms of drive architecture, hybrid vehicles are considered as series, parallel, and series-parallel (combined or power-split) hybrid systems. In a series hybrid structure, the internal combustion engine is solely responsible for electricity generation and has no mechanical connection to the wheels. In parallel hybrid systems, the internal combustion engine and electric motor are mechanically connected to the wheels and can provide propulsion either together or separately. Series-parallel hybrid systems combine the advantages of both architectures, allowing engine power to be transmitted both mechanically and electrically, thereby achieving higher efficiency under different driving conditions. In the classification based on the degree of hybridisation, micro (or mild), medium and full hybrid vehicles come to the fore. In micro and mild hybrid systems, the electric motor generally plays a supporting role, while in full hybrid vehicles, it is possible to drive solely on electric power for limited distances. In addition to this group, plug-in hybrid electric vehicles (PHEVs), which can be charged from an external source, offer a longer electric driving range thanks to their higher battery capacities. Classification based on the nature of the energy source includes electric-internal combustion engine hybrids and fuel cell hybrid systems. Fuel cell hybrid vehicles typically have a series hybrid architecture, with the fuel cell serving as the primary energy source and the battery or supercapacitors used to meet sudden power demands [13]. Figure 3 shows hybrid vehicles in terms of drive architecture.

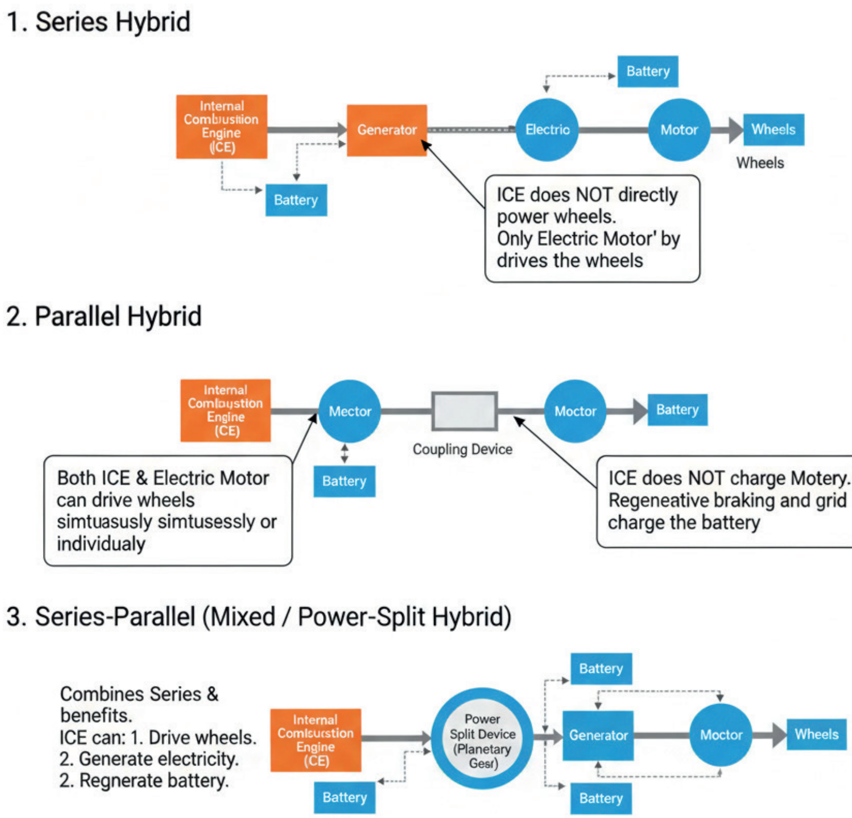

Figure 3. Hybrid vehicles in terms of drive architecture

The most significant advantages of hybrid electric vehicles include improved fuel economy, reduced emissions and the elimination of range anxiety. However, increased system complexity, relatively high purchase costs and partial dependence on fossil fuels are considered to be the main limitations of these vehicles.

3.3. Fuel Cell Electric Vehicles (FCEV)

In fuel cell electric vehicles, electrical energy is produced through electrochemical reactions between hydrogen and oxygen. In these systems, the electric motor serves as the primary propulsion element, while the battery is typically used as an auxiliary energy storage unit. The fact that only water vapour is emitted during operation makes these vehicles an environmentally appealing alternative [14].

The basic components of FCEVs include high-pressure hydrogen storage tanks, a fuel cell stack, an electric motor, and a small-capacity battery system. The fuel cell stack generates electricity through the reaction of hydrogen and oxygen, and the resulting energy is transferred directly to the electric motor. Energy recovered during regenerative braking is stored in the battery [15]. Figure 4 shows a schematic representation of fuel cell vehicle components.

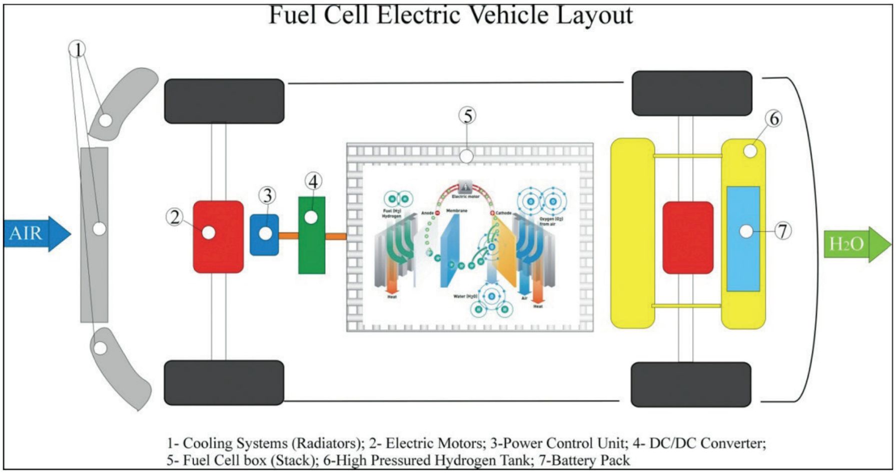

Figure 4. Schematic representation of fuel cell vehicle components [16]

Fuel cell electric vehicles offer significant advantages such as zero-emission operation, long driving range, and short refuelling times. However, the energy-intensive nature of hydrogen production, the limited availability of hydrogen production based on renewable sources, and the lack of hydrogen refuelling infrastructure are among the main obstacles to the widespread adoption of this technology. Furthermore, high system costs and ongoing research into the long-term durability of fuel cells are considered important issues to be addressed in the development process of FCEV technology [17].

4. Basic Technical Components of Electric Vehicles

The performance, efficiency and reliability of electric vehicles depend on the design and integration of their technical components. These components cover a wide range, from the vehicle's energy storage system (usually a battery) to the electric motor, power electronics systems and energy management systems. The correct selection and integration of each component has a direct impact on the overall performance of electric vehicles.

4.1. Electric Motors

One of the most important components directly determining the performance of the drive system in electric vehicles is the electric motor. In the literature, motors used in electric vehicle applications are examined in five main groups: DC brushed motors, DC brushless motors, asynchronous (induction) motors, synchronous motors, and switched reluctance motors. These motor types exhibit different characteristics in terms of criteria such as power-to-weight ratio, torque-speed characteristics, efficiency, control complexity, and cost [18]. Figure 5 schematically illustrates some characteristics of different types of electric motors.

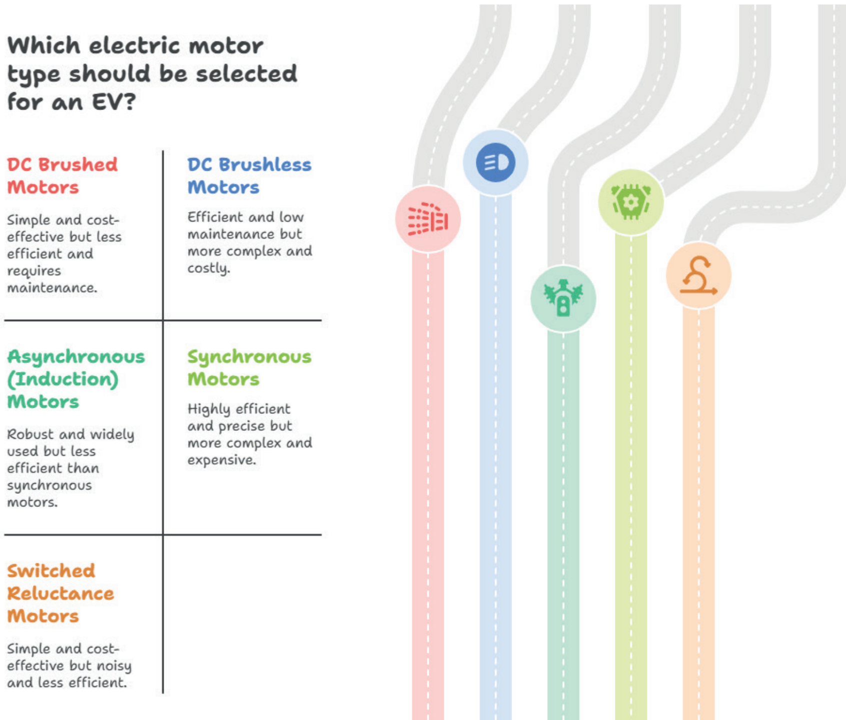

Figure 5. Schematic representation of some characteristics of different types of electric motors

Brush-type DC motors have been widely favoured in early applications of electric vehicles due to their high starting torque and simple control structures. However, mechanical wear caused by brushes and commutators increases maintenance requirements and limits maximum operating speed. Furthermore, their relatively low power density restricts the use of these motors in modern electric vehicles [18].

Brushless DC motors (BLDC) offer higher efficiency, longer service life and lower maintenance requirements thanks to the electronic implementation of mechanical commutation. High power-to-weight ratios and good speed-torque characteristics make BLDC motors attractive for electric vehicle applications. However, the high cost of these motors' drivers and control systems is considered a significant disadvantage [18].

Asynchronous motors are another type of motor widely used in electric vehicles due to their robust construction, high reliability and lack of a commutator. Their ability to operate across a wide speed range and deliver high efficiency at both full and partial loads are key factors in their popularity. However, the limited operating range in the constant power region can impose performance constraints under certain driving conditions [18].

Keyed reluctance motors, on the other hand, stand out due to their simple rotor structures, high starting torques, and ability to operate across a wide speed range. Furthermore, these motors are considered a potential alternative for electric vehicles due to their fault tolerance and relatively low motor and driver costs. However, issues such as torque fluctuations and acoustic noise are among the factors limiting the widespread use of these motors [18].

Ultimately, the selection of the motor type used in electric vehicles depends on numerous parameters, including vehicle performance, energy efficiency, cost, and intended use. Therefore, different motor types are evaluated according to different electric vehicle architectures and driving requirements.

4.2. Power Electronics Systems

Power electronics systems are one of the fundamental components of electric vehicles and convert the direct current obtained from the battery into the alternating current required for the electric motor. These systems consist of two main components: inverters and converters.

Inverters: Inverters convert the direct current power from the battery into the alternating current power required for the electric motor to operate. The efficiency of inverters has a direct impact on motor performance and the vehicle's overall energy consumption. Modern inverters use high switching frequencies and advanced control algorithms to achieve high efficiency and low harmonic distortion[19].

Converters: Converters perform energy conversion between different voltage levels. For example, they are used to step up or step down the battery voltage to the voltage level required by the motor or other auxiliary systems.

Converters can be of different types, such as DC-DC (Direct Current - Direct Current) and AC-DC (Alternating Current - Direct Current)[19].

The switching frequencies of power electronics systems are critical in terms of efficiency and thermal management. Higher switching frequencies allow for the use of smaller and lighter components, but they can also increase switching losses. Therefore, in power electronics design, a careful balance must be struck between switching frequency, efficiency, size, and cost.

4.3. Energy Management Systems

Energy management systems optimise the flow of energy between the battery, motor and auxiliary systems in electric vehicles, thereby increasing the vehicle's efficiency and range. Energy management systems develop and implement strategies to reduce energy consumption based on driving conditions, battery status and driver preferences.

The basic functions of energy management systems are as follows:

Battery Management: The battery management system extends battery life and ensures safety by controlling the battery's charging and discharging processes. The battery management system continuously monitors the voltage, temperature, and current of the battery cells and activates protection mechanisms in cases of overcharging, over-discharging, and overheating [20].

Motor Control: The motor control system adjusts the motor's torque and speed according to the driver's demands. This system optimises the motor's efficiency, reducing energy consumption and improving driving performance [20].

Regenerative Braking: The regenerative braking system converts the vehicle's kinetic energy into electrical energy to charge the battery. This system extends the vehicle's range, particularly in urban driving, by increasing energy recovery [20].

Management of Auxiliary Systems: Energy management systems optimise the energy consumption of auxiliary systems such as air conditioning, heating, lighting, and others. For example, smart algorithms can be used to ensure that the air conditioning system only operates when necessary, thereby reducing its energy consumption [20].

Energy management systems are critical for increasing the efficiency and range of electric vehicles. Using advanced control algorithms and sensor technologies, the performance of energy management systems is continuously being improved.

5. Energy Storage Systems and Battery Technologies

Energy storage systems directly affect the range, performance and service life of electric vehicles.

5.1. Battery Technologies Used in Electric Vehicles

In electric vehicles, batteries are considered fundamental energy storage components that directly affect the vehicle's range, performance, safety, and total cost of ownership. Advances in battery technology have played a decisive role in the commercial proliferation of electric vehicles. Batteries preferred for electric vehicle applications are expected to have high energy density, long cycle life, low energy loss, sufficient power density, and safe operating characteristics. Different battery types have been used throughout history to meet these requirements [21].

Lead-acid batteries are one of the oldest rechargeable battery types used in electric vehicles. Although they have been preferred for many years due to their low cost and mature production technologies, their low specific energy values, limited cycle life, and high mass have made them disadvantageous for modern electric vehicle applications. Today, lead-acid batteries are mostly limited to electric two-wheeled vehicles, forklifts, and applications requiring low speeds [21].

Nickel-cadmium batteries, despite offering a longer cycle life and better power performance compared to lead-acid batteries, have not found widespread use in the electric vehicle market due to cadmium being a toxic heavy metal and their relatively low energy density. Similarly, nickel-metal hydride batteries offered higher energy density and a more environmentally acceptable structure than nickel-cadmium batteries. Thanks to these characteristics, they were used for a certain period, particularly in hybrid electric vehicles, but lost their competitive edge with the development of lithium-based batteries [21].

Lithium-ion batteries are currently the most widely used energy storage technology in electric vehicles. These batteries offer significant advantages for electric vehicle applications due to their high specific energy and energy density, low self-discharge rate, long cycle life, and relatively lightweight construction. Furthermore, the absence of the memory effect is another important factor that increases the efficiency of lithium-ion batteries. These characteristics contribute to increasing the range of electric vehicles and improving overall system efficiency [21].

5.2. Battery Management Systems

Battery management systems are considered fundamental control and monitoring units that ensure electric vehicle batteries operate safely, efficiently, and with a long service life. These systems aim to enhance battery performance and durability by balancing cell voltages, maintaining battery temperature under control, and ensuring critical parameters such as voltage, current, and temperature remain within safe operating limits. Furthermore, battery management systems prevent battery overload by optimising charging and discharging processes, thereby supporting system safety. Predicting internal parameters such as the battery's state of charge and health allows for the evaluation of the battery's current capacity and remaining service life. Furthermore, recording operational data and sharing it with vehicle control systems contributes to monitoring battery performance and optimising vehicle operation. Battery management system structures, supported by advanced sensing and control algorithms, are among the critical systems that directly affect the safety, efficiency, and service life of electric vehicle batteries [22].

5.3. Promising Battery Technologies

Various alternative battery technologies are being developed to overcome the current limitations of lithium-ion batteries and further enhance the performance of electric vehicles.

Solid-State Batteries: Solid-state batteries use a solid electrolyte instead of a liquid electrolyte. This increases the battery's energy density, improves its safety, and enables faster charging. Solid-state batteries are more stable and less flammable than lithium-ion batteries, which reduces the risk of fire. Furthermore, as they have a higher energy density, they can increase the range of electric vehicles [23].

Lithium-Sulphur Batteries: Lithium-sulphur batteries have a higher theoretical energy density than lithium-ion batteries. Sulphur is a more abundant and cheaper material than lithium, so these batteries may offer a cost advantage. However, lithium-sulphur batteries need improvement in areas such as cycle life and charge/discharge speed [23].

Sodium-Ion Batteries: Sodium-ion batteries use sodium instead of lithium. Sodium is a more abundant and cheaper element than lithium. These batteries may be suitable for large-scale applications, such as energy storage systems [23].

6. Charging Infrastructure and Network Integration

As electric vehicles become more widespread, the adequacy, reliability and accessibility of the charging infrastructure emerge as critical determinants. The level of development of the charging infrastructure reduces users' range anxiety and directly affects the integration of electric vehicles into daily transport systems. In this context, various charging technologies have been developed and implemented for different power levels and usage scenarios.

Alternating current (AC) slow charging systems are generally preferred in homes, workplaces and long-term parking areas. These systems operate at relatively low power levels and ensure that batteries are charged over longer periods of time. The positive effects of slow charging on battery life make this method a suitable option for daily use. Direct current (DC) fast charging systems, on the other hand, operate at higher power levels, enabling batteries to be charged significantly in a short time. These systems are particularly favoured on motorways, inter-city routes and in high-traffic areas, increasing the usability of electric vehicles for long-distance travel. Ultra-fast charging technologies, on the other hand, aim to reduce charging times to levels comparable to conventional fuel refuelling by offering much higher power levels; however, the widespread adoption of these systems is closely linked to technical limitations such as battery thermal management and grid capacity [24], [25].

The interaction between charging infrastructure and the electricity grid is becoming increasingly complex with the widespread adoption of electric vehicles. Charging a large number of vehicles simultaneously can place additional strain on distribution networks in particular. In this context, smart charging systems are considered an important solution for balancing grid load and ensuring the efficient use of energy resources. Smart charging approaches aim to optimise charging processes by taking into account parameters such as grid conditions, energy prices and user preferences [26].

Vehicle-to-Grid (V2G) applications, defined as the transfer of energy from the vehicle to the grid, enable electric vehicles to be considered not only as energy consumers but also as distributed energy storage units [27]. Thanks to this approach, the energy stored in electric vehicle batteries can be used via feedback during periods of high grid demand. V2G systems facilitate the integration of renewable energy sources into the grid and contribute to maintaining the energy supply-demand balance. However, the widespread adoption of these applications requires comprehensive consideration of issues such as battery life, standardisation, infrastructure investments, and regulatory frameworks.

7. Environmental Impacts

Life cycle analysis is used as a fundamental approach in assessing the environmental impacts of electric vehicles. This analysis method comprehensively addresses the environmental performance of electric vehicles by covering the stages of raw material sourcing, production, use and recycling. Battery production processes, in particular, stand out as one of the stages where environmental impacts are concentrated due to energy consumption and raw material use. However, advances in battery recycling technologies and improvements in production processes contribute to reducing these impacts. The environmental impacts of electric vehicles during the usage phase largely depend on the structure of the energy sources used in electricity generation. Increasing the share of renewable energy sources in electricity generation significantly reduces the total greenhouse gas emissions and environmental footprint of electric vehicles. Furthermore, the elimination of exhaust emissions contributes significantly to improving urban air quality.

8. Future-Oriented Technological Trends

The future of electric vehicle technology is being shaped by advances in digitalisation and energy storage. Autonomous driving systems, artificial intelligence-supported energy management and advanced battery chemistries are among the key technological components of this transformation.

Autonomous driving technologies aim to increase driving safety and improve traffic efficiency through advanced sensing and control systems. The software-based structure of electric vehicles facilitates the integration of these systems [28]. Artificial intelligence-supported energy management optimises energy consumption [29], extends battery life and improves vehicle performance by taking driving conditions and user behaviour into account.

New generation chemistries developed in battery technologies are advancing towards higher energy density, shorter charging times, and increased safety targets. These developments are expected to contribute to electric vehicles becoming more competitive in terms of range and cost. Overall, these technological trends are strengthening the role of electric vehicles within sustainable and smart transportation systems.

9. Conclusion and Evaluation

Electric vehicles stand out as a strategic technology area in line with the objectives of increasing energy efficiency, reducing greenhouse gas emissions, and developing sustainable transport systems. Both the structural advantages in propulsion systems and the elimination of local emissions place electric vehicles in an important position among future transport solutions.

Advances in battery technology play a decisive role in improving the range, performance, and safety features of electric vehicles. In parallel, the widespread deployment of charging infrastructure and its planning in harmony with the electricity grid are making electric vehicles more accessible for everyday use. The shaping of energy policies to support renewable energy sources further strengthens the environmental benefits of electric vehicles.

In this context, addressing the technical, environmental and economic dimensions of electric vehicle technologies together is important for both academic research and industrial applications. A holistic approach will contribute to increasing the share of electric vehicles in transport systems and support the achievement of sustainable mobility goals.

References

[1] G. Öztürk, A. Aslan, and M. Fırat, The Effect of Dibutyl Maleate Additive on Combustion Characteristics in Compression Ignition Engines and Analysis of Performance Prediction Based on Machine Learning. 2025.

[2] Ö. Karaman, A. Aslan, G. Öztürk, and M. Canpolat, Machine Learning Algorithms For Electric Vehicle Charging Station Energy Consumption Prediction. 2025.

[3] Y. Altunkaynak and M. Canpolat, 'Effective removal of Cu (II) ions from aqueous solutions using low-cost, eco-friendly natural and modified potato peels', Environ Monit Assess, vol. 197, no. 3, p. 309, Feb. 2025, doi: 10.1007/s10661-025-13762-8.

[4] M. Canpolat, 'Removing Co(II) and Mn(II) ions effectively from aqueous solutions by means of chemically non-processed Mardin stone waste: Equivalent, kinetic, and thermodynamic investigations', Environmental Progress & Sustainable Energy, vol. 42, no. 3, p. e14042, 2023, doi: 10.1002/ep.14042.

[5] M. Canpolat and Y. Altunkaynak, 'Use of low-cost processed orange peel for effective removal of cobalt (II) and manganese (II) from aqueous solutions', Ionics, vol. 30, no. 1, pp. 591–605, Jan. 2024, doi: 10.1007/s11581-023-05291-6.

[6] G. Öztürk, M. N. Tansu, and U. Uz, 'Türkiye'de Hibrid Ve Elektrikli Araçlara Eğilimin Araştırılması', Ejons International Journal on Mathematic, Engineering and Natural Sciences, vol. 5, no. 20, pp. 814–823, Dec. 2021, doi: 10.38063/ejons.517.

[7] K. G. Høyer, 'The history of alternative fuels in transportation: The case of electric and hybrid cars', Utilities Policy, vol. 16, no. 2, pp. 63–71, June 2008, doi: 10.1016/j.jup.2007.11.001.

[8] M. Singh, 'Green Energy for Metropolitan Transport', International Journal on Power Engineering and Energy.

[9] M. Valenta, 'Doctor of Business Administration'.

[10] A. Kerem, 'Elektrikli Araç Teknolojisinin Gelişimi ve Gelecek Beklentileri', 2014.

[11] A. Faraz, A. Ambikapathy, S. Thangavel, K. Logavani, and G. Arun Prasad, 'Battery Electric Vehicles (BEVs)', in Electric Vehicles: Modern Technologies and Trends, N. Patel, A. K. Bhoi, S. Padmanaban, and J. B. Holm-Nielsen, Eds, Singapore: Springer, 2021, pp. 137–160. doi: 10.1007/978-981-15-9251-5_8.

[12] M. A. Hannan, F. A. Azidin, and A. Mohamed, 'Hybrid electric vehicles and their challenges: A review', Renewable and Sustainable Energy Reviews, vol. 29, pp. 135–150, Jan. 2014, doi: 10.1016/j.rser.2013.08.097.

[13] M. Kebriaei, A. H. Niasar, and B. Asaei, ‘Hybrid electric vehicles: An overview’, in 2015 International Conference on Connected Vehicles and Expo (ICCVE), Oct. 2015, pp. 299–305. doi: 10.1109/ICCVE.2015.84.

[14] T. Selmi, A. Khadhraoui, and A. Cherif, ‘Fuel cell–based electric vehicles technologies and challenges’, Environ Sci Pollut Res, vol. 29, no. 52, pp. 78121–78131, Nov. 2022, doi: 10.1007/s11356-022-23171-w.

[15] M. Muthukumar, N. Rengarajan, B. Velliyangiri, M. A. Omprakas, C. B. Rohit, and U. Kartheek Raja, ‘The development of fuel cell electric vehicles – A review’, Materials Today: Proceedings, vol. 45, pp. 1181–1187, Jan. 2021, doi: 10.1016/j.matpr.2020.03.679.

[16] B. Tanç, H. T. Arat, E. Baltacıoğlu, and K. Aydın, ‘Overview of the next quarter century vision of hydrogen fuel cell electric vehicles’, International Journal of Hydrogen Energy, vol. 44, no. 20, pp. 10120–10128, Apr. 2019, doi: 10.1016/j.ijhydene.2018.10.112.

[17] A. Pramuanjaroenkij and S. Kakaç, ‘The fuel cell electric vehicles: The highlight review’, International Journal of Hydrogen Energy, vol. 48, no. 25, pp. 9401–9425, Mar. 2023, doi: 10.1016/j.ijhydene.2022.11.103.

[18] S. Ravindra Jape and A. Thosar, ‘Comparison Of Electric Motors For Electric Vehicle Application’, IJRET, vol. 06, no. 09, pp. 12–17, Sept. 2017, doi: 10.15623/ijret.2017.0609004.

[19] C. C. Chan and K. T. Chau, ‘An overview of power electronics in electric vehicles’, IEEE Transactions on Industrial Electronics, vol. 44, no. 1, pp. 3–13, Feb. 1997, doi: 10.1109/41.557493.

[20] D. Rimpas et al., ‘Energy management and storage systems on electric vehicles: A comprehensive review’, Materials Today: Proceedings, vol. 61, pp. 813–819, Jan. 2022, doi: 10.1016/j.matpr.2021.08.352.

[21] S. Muslimin, Z. Nawawi, B. Y. Suprapto, and T. Dewi, ‘Comparison of Batteries Used in Electrical Vehicles’, presented at the 5th FIRST T1 T2 2021 International Conference (FIRST-T1-T2 2021), Atlantis Press, Feb. 2022, pp. 421–425. doi: 10.2991/ahe.k.220205.074.

[22] R. Xiong and W. Shen, ‘Battery Management Systems in Electric Vehicles’, in Advanced Battery Management Technologies for Electric Vehicles, Wiley, 2019, pp. 231–248. doi: 10.1002/9781119481652.ch8.

[23] K. Itani and A. De Bernardinis, ‘Review on New-Generation Batteries Technologies: Trends and Future Directions’, Energies, vol. 16, no. 22, p. 7530, Jan. 2023, doi: 10.3390/en16227530.

[24] Ö. Karaman, S. Çelebi, and G. Öztürk, ‘Electric Vehicle Charging Stations and Harmonic Problem’, 2024, pp. 25–44.

[25] H. H. Wu, A. Gilchrist, K. Sealy, P. Israelsen, and J. Muhs, ‘A review on inductive charging for electric vehicles’, in 2011 IEEE International Ele-

ctric Machines & Drives Conference (IEMDC), May 2011, pp. 143–147. doi: 10.1109/IEMDC.2011.5994820.

[26] H. Tu, H. Feng, S. Srdic, and S. Lukic, 'Extreme Fast Charging of Electric Vehicles: A Technology Overview', IEEE Transactions on Transportation Electrification, vol. 5, no. 4, pp. 861–878, Dec. 2019, doi: 10.1109/TTE.2019.2958709.

[27] S. Çelebi, Ö. Karaman, and G. Öztürk, 'Autonomous Driving Technologies and Cyber Security in Vehicles', 2024, pp. 1–39.

[28] G. Öztürk, S. Çelebi, and Ö. Karaman, 'Autonomous Vehicles: Systems, Technologies and Sensors', 2024, pp. 34–81.

[29] A. Aslan, 'Deep Learning In Neurological Imaging: A Novel Cnn-Based Model For Brain Tumor Classification Türkiye And Health Risk Assessment', JHVS, vol. 13, no. 2, Art. no. 2, June 2025, doi: 10.33715/inonusaglik.1645318.