RESEARCH PAPER

Comprehensive Review of Intelligent Electric Vehicles: Technologies, Charging Infrastructure, Battery Systems, Challenges, and Future Perspectives

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ABSTRACT

Electric vehicles (EVs) are becoming a key part of cleaner and more sustainable transportation. They help reduce greenhouse gas emissions, use energy more efficiently, and lower our dependence on fossil fuels. This paper gives an overview of intelligent electric vehicles and looks at important topics such as the different types of EVs based on their engine technology and powertrain setup, battery performance, charging methods, and the infrastructure needed to support charging.

The paper also reviews recent studies on machine learning, energy management, energy trading, and cybersecurity, all of which play an important role in building smarter EV systems. In addition, it discusses the main problems linked to EV charging stations, including high setup costs, long charging times, difficulties with grid integration, compatibility issues, battery aging, and cybersecurity risks.

Battery features in different types of EVs are also compared to show how they affect vehicle performance and charging needs. The paper further explores future research areas, such as better battery technologies, faster charging systems, Vehicle-to-Grid (V2G) integration, artificial intelligence, blockchain-based energy trading, and secure communication systems. In the end, the review shows that continued progress in batteries, smart charging, intelligent control, and cybersecurity will be necessary to make electric mobility more reliable, efficient, and sustainable in the future.

Keywords: Electric vehicles, Intelligent EVs, Charging infrastructure, Battery systems, Energy management, V2G, Cybersecurity, Machine learning, Sustainable transportation.

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Introduction:

The transportation sector is changing rapidly as the world looks for ways to reduce greenhouse gas emissions, improve energy efficiency, and create more sustainable mobility systems. For many years, conventional vehicles powered by internal combustion engines have been a major cause of urban air pollution and global carbon emissions, leading to serious environmental and public health problems. Because of these concerns, electric vehicles (EVs) have gained attention as a cleaner and more practical alternative [1] [2] [3]. They offer better energy efficiency, lower running costs, reduced maintenance needs, and no tailpipe emissions. At the same time, progress in renewable energy and smart grid technologies has made it easier to integrate EVs into today's power systems [4]. As countries continue working toward carbon neutrality and stronger energy security, EVs are no longer seen only as a means of transport. They are increasingly recognized as flexible energy resources that can help stabilize the grid, support the use of renewable energy, and improve overall energy management [5].

Alongside this shift, digital technologies have significantly expanded the potential of EV ecosystems. The use of machine learning, energy trading platforms, and cybersecurity frameworks is making electric mobility more intelligent, efficient, and connected. Machine learning can improve battery management, support predictive maintenance, optimize charging schedules, forecast energy use, and assist with autonomous driving functions, all of which enhance both vehicle performance and user experience [26]. In addition, technologies such as vehicle-to-grid (V2G) and vehicle-to-everything (V2X) allow EVs to interact more actively with smart grids and participate in two-way energy exchange. This opens the door to more dynamic energy trading and better use of available power resources. However, greater connectivity also brings new risks. EV systems can become vulnerable to cyber threats such as unauthorized access, data breaches, communication attacks, and even manipulation within energy markets. For this reason, it is important to develop a clear understanding of EV technologies, intelligent control systems, energy trading models, and cybersecurity challenges as connected parts of the same system. This review explores these areas together and highlights recent developments, current research trends, major challenges, and future opportunities in intelligent electric mobility [6].

Literature Review:

Recent studies on intelligent electric vehicles have mostly centered on three closely related areas: machine learning, energy trading, and cybersecurity. Research by Brighente et al. (2023), Mitikiri et al. (2023), and Razzaque et al. (2025) points to the growing range of cybersecurity risks within EV systems, especially in charging stations, communication networks, and Vehicle-to-Grid (V2G) infrastructure. To deal with these issues, many researchers have suggested solutions such as machine learning-based intrusion detection, blockchain-supported security models, and secure communication protocols aimed at improving the privacy and resilience of EV networks. Other review studies on cyberattacks and security frameworks have also stressed the importance of using combined protection strategies that bring together artificial intelligence, blockchain, and stronger encryption methods.

At the same time, there has been notable progress in applying machine learning and smart energy management to EV integration. Studies by Wang et al. (2023), Kaur et al. (2024), and Ali et al. (2024) showed that AI-based methods can effectively support load forecasting, demand response, energy storage optimization, and intelligent charging management. In the area of energy trading, Xu et al. (2024) and Aoudia et al. (2024) examined Vehicle-to-Vehicle (V2V) and blockchain-based peer-to-peer trading systems, which allow decentralized and secure energy exchange. Research on V2G technologies, digital twins, and smart charging strategies has also demonstrated strong potential for improving grid stability, increasing the use of renewable energy, and boosting overall operational efficiency. Even with these developments, the existing literature still shows a clear need for broader frameworks that can address intelligent energy management, secure energy trading, and strong cybersecurity together within future EV ecosystems.

Ref. No.	**Author(s) & Year**	**Research Focus**	**Key Findings**
[7]	Brighente et al. (2023)	EV Security and Privacy	Provided a broad review of cybersecurity threats affecting EVs, including weaknesses in charging infrastructure, privacy concerns, and the security needs of

			future EV ecosystems.
[8]	Mitikiri et al. (2023)	EV Charging Infrastructure Security	Examined EV charging infrastructure as a cyber-physical system, with attention to standards, communication protocols, possible vulnerabilities, and common attack paths.
[9]	Wang et al. (2023)	AI-Based Energy Management	Explored the use of AI and machine learning for load forecasting, anomaly detection, and demand response in smart energy systems connected to EVs.
[10]	Xu, Peralta & Balta-Ozkan (2024)	Vehicle-to-Vehicle (V2V) Energy Trading	Carried out a systematic review of Vehicle-to-Vehicle (V2V) energy trading frameworks, focusing on optimization approaches, trading models, and practical implementation issues.
[11]	Aoudia et al. (2024)	Blockchain-Based Energy Trading	Surveyed blockchain-based energy trading between EVs and smart grids, highlighting secure transactions, IoT connectivity, and decentralized market structures.
[12]	Rana et al. (2024)	Vehicle-to-Grid (V2G) Technology	Reviewed bidirectional charger designs and control methods for Vehicle-to-Grid (V2G) applications, especially in relation to grid stability and energy efficiency.
[13]	Review by e-Prime Authors (2024)	AI and Machine Learning in V2G	Investigated machine learning-driven charging control, bidirectional converters, smart charging methods, and intelligent grid integration.
[14]	Heluany & Gkioulos (2024)	Digital Twins for Smart Grids	Discussed digital twin applications in power generation and distribution, showing their value for EV fleet management and predictive maintenance.
[15]	Kaur et al. (2024)	Demand Response	Analyzed EV demand response

		Management	models, load forecasting methods, optimization techniques, and secure energy management strategies within smart grids.
[16]	Wu et al. (2024)	Machine Learning-Based Cybersecurity	Proposed behavior-based machine learning methods to detect malicious EV activity in V2G systems and strengthen grid reliability.
[17]	Ali et al. (2024)	EV Energy Storage Integration	Reviewed machine learning techniques that support the use of EVs as mobile battery storage systems and improve overall energy management.
[18]	Survey by Cybersecurity Researchers (2024)	EV Cyberattack Analysis	Presented a classification of cyberattacks targeting EVs, including risks to system confidentiality, integrity, and availability.
[19]	Razzaque et al. (2025)	V2G Cybersecurity	Conducted a systematic review of cybersecurity challenges in V2G systems, identifying vulnerabilities, attack types, and AI-based protection methods.
[20]	Razzaque et al. (2025)	AI and Blockchain Security	Pointed out research gaps related to AI assurance, blockchain security, and quantum-safe encryption in V2G networks.
[21]	Yang et al. (2024)	Fuzzy ML and Blockchain Security	Investigated the use of fuzzy machine learning and blockchain for cloud-based EV cybersecurity and secure energy transactions.
[22]	Sarieddine et al. (2024)	EV Charging Station Security	Proposed edge-based detection approaches for identifying cyberattacks on EV charging stations and smart grid systems.
[23]	Wu et al. (2024)	Secure Smart Transportation	Examined recent machine learning developments aimed at improving the security

			of smart transportation systems and making EV communication networks more resilient.
[24]	Recent V2G Studies (2024)	Intelligent Charging Control	Showed how AI can help optimize charging schedules, lower peak electricity demand, and improve the use of renewable energy.
[25]	Recent Blockchain-Energy Trading Studies (2024)	Peer-to-Peer Energy Markets	Evaluated decentralized peer-to-peer energy trading architectures that allow EVs to participate in transactive energy systems.
[26]	Recent EV Security Surveys (2024–2025)	Integrated EV Cybersecurity Frameworks	Emphasized the importance of integrated frameworks that combine machine learning, blockchain, intrusion detection, and secure communication protocols for future intelligent EV ecosystems.

Table1: Literature Review [7-26]

Classification of Electric Vehicles (EVs) According to Engine Technologies and Powertrain Configuration

Electric vehicles can be grouped in different ways, such as by the type of propulsion technology they use, how their powertrain is designed, the kind of motor they rely on, and where their energy comes from. Among these types, Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) are the most widely used today because they are efficient and are supported by an expanding charging network [21]. Other types, including hybrid vehicles, fuel-cell vehicles, and solar-powered vehicles, also provide useful alternatives by helping extend driving range, lower emissions, and support more sustainable transportation [22].

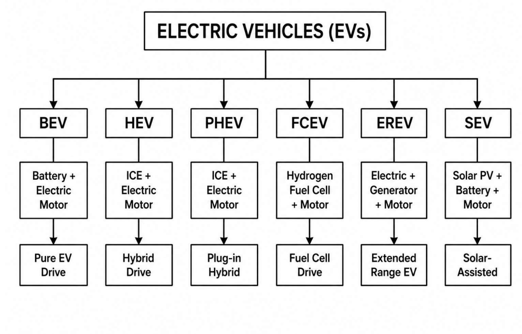


Fig. 1 Classification of Electric Vehicles

Hybrid Powertrain Configurations [27]

(a) Series Hybrid

In a Series Hybrid Electric Vehicle (HEV), the internal combustion engine does not power the wheels directly. Instead, it runs a generator that produces electricity. That electricity can either be sent to the battery for storage or delivered straight to the electric motor. The motor is the only part responsible for driving the wheels and moving the vehicle. This setup can improve fuel efficiency and provide smoother performance, especially in city driving where stop-and-go traffic is common. Early versions of the Chevrolet Volt are often mentioned as an example of this type of hybrid system [27].

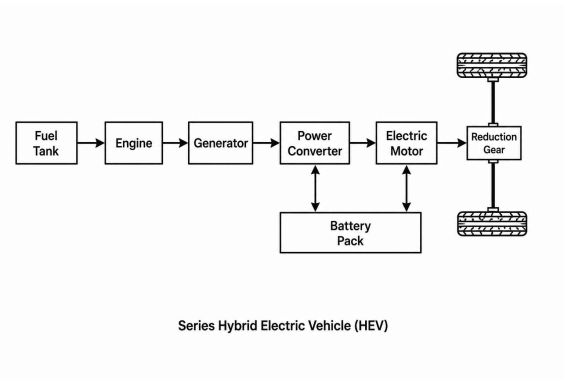


Fig. 2. Series Hybrid Vehicle

(b) Parallel Hybrid Electric Vehicle (HEV)

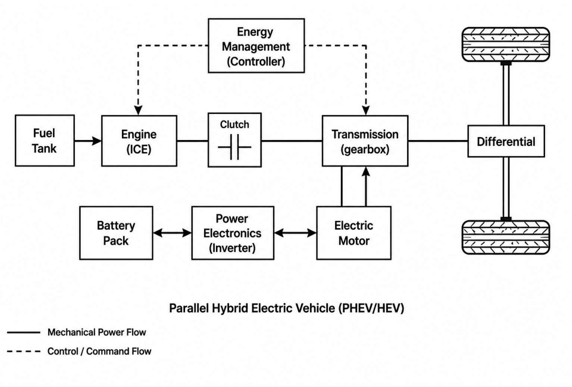


Fig.3. Parallel Hybrid Electric Vehicle (HEV)

A Parallel Hybrid Electric Vehicle (HEV) uses both an internal combustion engine and an electric motor to move the vehicle. Unlike a series hybrid, both of these power sources are mechanically linked to the transmission, which means each of them can directly send power to the wheels. The electric motor gets its energy from the battery through power electronics such as an inverter, while the engine is powered by fuel from the tank. A control system manages how the engine and motor work together so the vehicle can deliver good performance while using fuel as efficiently as possible [27].

At lower speeds, the vehicle may run only on the electric motor, which helps reduce fuel use and emissions. When more power is needed, such as during faster driving or acceleration, the engine and motor can operate together. During braking, the electric motor can also act as a generator, recovering some of the vehicle's kinetic energy and storing it back in the battery. This design helps improve fuel economy, increase driving range, and boost overall efficiency. Because it offers a good balance between performance and energy savings, the parallel hybrid system is widely used in many commercial hybrid vehicles.

(c) Series-Parallel (Power-Split) Hybrid

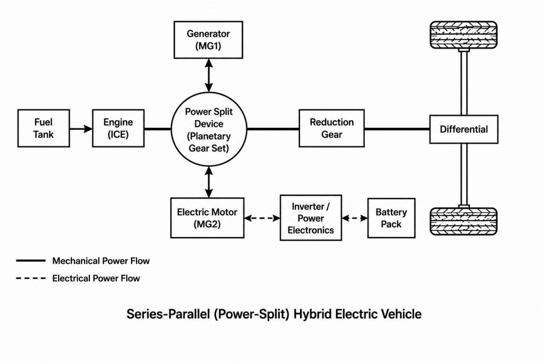


Fig.4. Series-Parallel (Power-Split) Hybrid

A Series–Parallel Hybrid Electric Vehicle (HEV), often called a power-split hybrid, combines features of both series and parallel hybrid systems. In this design, the internal combustion engine, electric motor, generator, and battery pack work together through a power-split device, which is usually a planetary gear set. This device allows the engine's power to be directed in different ways—either straight to the wheels through a mechanical connection or to the generator to produce electricity. The electricity that is generated can then be used to charge the battery or power the electric motor [27].

Because of this setup, the vehicle can switch between different operating modes depending on driving needs. It may run only on electric power at low speeds, use only the engine in some situations, or combine both the engine and the motor when extra power or better efficiency is needed. During braking, regenerative braking helps recover energy and store it back in the battery. This flexibility gives the system strong fuel economy, smooth energy management, and good overall performance. For these reasons, the series–parallel hybrid design is widely used in modern hybrid vehicles, with the Toyota Prius being one of the best-known examples.

Classification Based on Motor Technology

Electric vehicles use different types of electric motors depending on the level of performance needed and the type of application. One of the most common choices in modern EVs is the Permanent Magnet Synchronous Motor (PMSM), mainly because it offers high efficiency and strong power density. The Brushless DC Motor (BLDC) is also widely valued for its simple design, dependable operation, and easy control, which makes it a good fit for lighter electric vehicles.

The Induction Motor (IM) is well known for being rugged, durable, and requiring relatively little maintenance. The Switched Reluctance Motor (SRM), on the other hand, is often seen as a cost-effective option because it can perform reliably even in harsh conditions and has strong fault tolerance. Another promising option is the Synchronous Reluctance Motor (SynRM), which can deliver better efficiency while reducing reliance on expensive rare-earth materials. Because of this, it is increasingly viewed as a strong candidate for future EV applications [28].

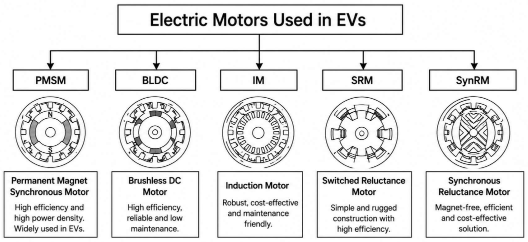


Fig.5. Electric Motors used in EVs

Classification Based on Energy Source

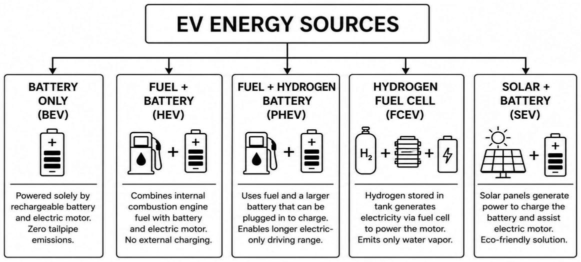


Fig.6. Classification Based on Energy Source

Electric Vehicle Charging Methods

Electric vehicle batteries operate on direct current (DC), which means they can only store and use DC electricity. The problem is that the power grid supplies alternating current (AC), so the electricity has to be converted before it can charge the battery. In AC charging, this conversion happens inside the vehicle through the onboard charger, which changes AC power into DC before sending it to the battery. In DC charging, the conversion takes place in the charging station instead, so DC power is supplied directly to the battery. Because it skips the vehicle's onboard charger, DC charging is much faster [29].

EV charging systems are usually divided into four main charging modes. Modes 1, 2, and 3 are based on AC charging, while Mode 4 uses DC charging. Modes 1 and 2 rely on a standard electrical outlet and a charging cable. Mode 1 is the most basic form of charging and does not include communication between the vehicle and the charging equipment, which is why it is generally not recommended. Mode 2 adds built-in protection and control features to the cable, making it more suitable for home use. Modes 3 and 4 use dedicated charging equipment with better safety and control systems. These are the types most often found in public and commercial charging stations, where they provide charging that is faster, safer, and more efficient [30].

Power Ratings of EV Charging Stations (EVSE)

Charging Category	Power Rating	Charger Type	Suitable Vehicle Segment	Key Features
Normal Power AC Charging	Up to 22 kW	AC Charger	E-2Ws, E-3Ws, and E-Cars	Most common charging method; suitable for home, workplace, and public charging.
Single-Phase AC Charging	Up to 7 kW	AC Charger	E-2Ws, E-3Ws, and small E-Cars	Uses standard electricity supply; ideal for overnight charging.
Three-Phase AC Charging	7–22 kW	AC Charger	E-Cars with larger onboard chargers	Faster than single-phase charging; commonly used in commercial locations.
Normal Power DC Charging	Up to 22 kW	DC Charger	Low-voltage E-Cars and LEVs	Unique to India due to widespread use of low-voltage EV batteries.
High-Power DC Charging	25–60 kW (typically 50 kW)	DC Fast Charger	High-voltage E-Cars, LCVs, and MCVs	Provides significantly faster charging than AC charging.
Ultra-Fast DC Charging	60–200 kW	DC Fast Charger	Advanced E-Cars and Commercial EVs	Reduces charging time considerably but requires stronger grid infrastructure.
Heavy-Duty EV Charging	Up to 500 kW	Ultra-Fast DC Charger	Electric Buses and Trucks	Designed for large battery packs and heavy commercial vehicles.

Table 2. Power Ratings of EV Charging Stations (EVSE)

Normal charging power, usually up to 22 kW, is enough for most everyday EV charging needs and works especially well for overnight charging. Single-phase AC chargers, which are commonly rated up to 7 kW, are widely used for electric two-wheelers, three-wheelers, and smaller electric cars because they are compatible with typical residential electricity supplies. For quicker charging, many modern electric cars use three-phase AC chargers that can provide up to 22 kW. High-power DC chargers, usually in the range of 25 kW to 60 kW, are designed for higher-voltage EVs and can charge much faster because they deliver power directly to the battery. Ultra-fast chargers, which can reach up to 500 kW, are mainly intended for electric buses and heavy commercial vehicles, although they require more advanced electrical infrastructure and greater grid capacity [31].

EV charging stations, however, still face a number of challenges that can slow the wider adoption of electric mobility. One of the main issues is the high cost of installation and maintenance, along with the limited availability of charging infrastructure in many areas. Charging also takes much longer than refueling a conventional vehicle, which can be inconvenient for users. On a larger scale, increased EV charging can put extra pressure on the electricity grid, causing overloads, voltage instability, and power quality issues. Compatibility is another concern, since the lack of universal charging standards can create problems between different vehicles and charging systems. At the same time, integrating renewable energy sources and Vehicle-to-Grid (V2G) technologies calls for more advanced energy management. Other important concerns include cybersecurity risks, communication failures, battery wear caused by frequent fast charging, and the need to provide reliable, user-friendly charging services. Overcoming these challenges is essential for building an EV charging system that is efficient, secure, and sustainable [31].

Sr. No.	Challenge	Short Explanation
1	High Installation Cost	Charging stations require significant investment in equipment, land, and grid infrastructure.
2	Grid Overloading	Large-scale EV charging can increase peak demand and stress the electrical grid.
3	Long Charging Time	EV charging takes longer than conventional fuel refilling, causing user inconvenience.
4	Limited Charging Infrastructure	Insufficient charging stations, especially in rural and remote areas, create range anxiety.
5	Lack of Standardization	Different charging connectors and standards lead to compatibility issues.
6	Renewable Energy Integration	Variability of solar and wind power complicates charging station operation.
7	Battery Degradation	Frequent fast charging may reduce battery life and performance.
8	Land and Space Constraints	Urban charging stations require adequate parking and installation space.
9	Cybersecurity Risks	Charging networks are vulnerable to hacking, data theft, and communication attacks.
10	Communication Issues	Reliable communication is required between EVs, chargers, and grid operators.
11	Energy Management Challenges	Charging demand varies, requiring intelligent scheduling and load forecasting.
12	Vehicle-to-Grid (V2G) Complexity	Bidirectional power flow requires advanced control, communication, and regulations.
13	Maintenance and Reliability	Regular maintenance is necessary to ensure charger availability and safety.
14	User Acceptance	Fast charging, easy payment, and charger availability are essential for customer satisfaction.

Table 3. Challenges in EVs [32]

Overall, EV charging stations still face several important challenges, including high costs, pressure on the power grid, slow charging times, limited infrastructure, and cybersecurity risks. Solving these issues is essential if electric vehicles are to be adopted on a much larger scale.

Battery Performance Parameters of Different Electric Vehicle Segments

In India, the move toward electric transportation is being led mainly by light electric vehicles (LEVs), especially electric two-wheelers (E-2Ws) and electric three-wheelers (E-3Ws). These vehicles are widely used for daily personal travel as well as commercial transport. At the same time, electric cars and light commercial vehicles (LCVs) are also becoming more common, supported by growing environmental awareness and government initiatives [33].

Battery capacity and voltage needs differ depending on the type of vehicle, its required driving range, and its power demand. Smaller vehicles, such as e-scooters and e-rickshaws, usually use lower-voltage batteries with smaller energy capacity. In contrast, modern electric cars need larger, higher-voltage battery packs to deliver longer range and better performance. These differences in battery specifications have a direct effect on charging infrastructure, charging duration, and the overall efficiency of the vehicle [33].

Table 4: Battery Specifications of Different EV Segments

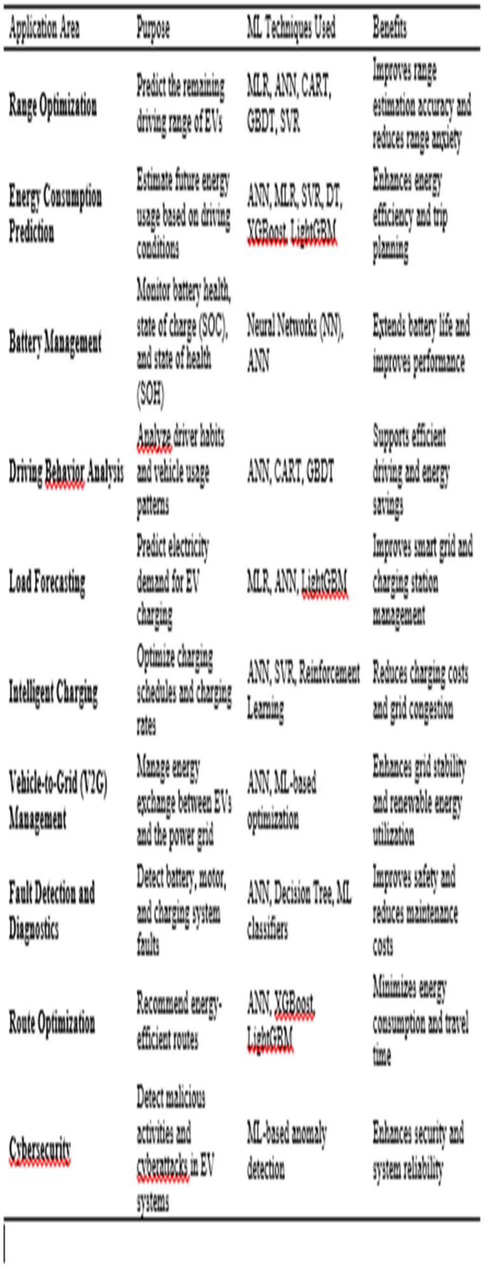
Vehicle Segment	**Battery Capacity**	**Battery Voltage**	**Description**
E-2W (Electric Two-Wheeler)	1.2–3.3 kWh	48–72 V	Used in electric scooters and motorcycles; suitable for short-distance urban travel.
E-3W (Electric Three-Wheeler)	3.6–8 kWh	48–60 V	Commonly used for passenger transport and goods delivery; offers moderate range and load capacity.
E-Cars (1st Generation)	21 kWh	72 V	Early electric car models with limited range; mainly used for city transportation and taxi services.
E-Cars (2nd Generation)	30–80 kWh	350–500 V	Modern electric cars with higher performance, faster charging capability, and extended driving range.
Electric LCVs	Varies with vehicle size	Low or High Voltage	Designed for commercial transportation; battery specifications depend on payload and operational requirements.

Electric two-wheelers (E-2Ws) and electric three-wheelers (E-3Ws) usually rely on low-voltage batteries, which makes them more affordable and practical for everyday city travel. In a similar way, first-generation electric cars also used low-voltage battery systems, although these models are gradually being replaced by newer and more advanced designs. By contrast, second-generation electric cars are built with high-voltage battery packs, typically in the range of 350 V to 500 V, allowing them to charge faster and travel longer distances. Electric light commercial vehicles (LCVs) can use either low-voltage or high-voltage battery systems, depending on how much load they carry and the type of work they are designed to do. Because of this, understanding battery characteristics such as voltage and capacity is very important when planning EV charging infrastructure. Charging systems must provide the correct voltage and current levels to ensure that batteries are charged safely, reliably, and efficiently.

Machine Learning Applications in Electric Vehicles (EVs)

Machine learning (ML) has become an important tool for improving the performance, efficiency, and reliability of electric vehicles. It works by analyzing large amounts of data related to the vehicle, battery condition, driving patterns, and surrounding environment. With this information, ML can help optimize driving range, estimate energy use more accurately, monitor battery health, and support smarter charging decisions. Since it can learn from both past and real-time data, machine learning often provides more accurate predictions than traditional methods. This can help reduce range anxiety and create a better overall experience for EV users [34].

Table 5: Applications of Machine Learning in Electric Vehicles



Application Area	Purpose	ML Techniques Used	Benefits
Range Optimization	Predict the remaining driving range of EVs	MLR, ANN, CART, GBDT, SVR	Improves range estimation accuracy and reduces range anxiety
Energy Consumption Prediction	Estimate future energy usage based on driving conditions	ANN, MLR, SVR, DT, XGBoost, LightGBM	Enhances energy efficiency and trip planning
Battery Management	Monitor battery health, state of charge (SOC), and state of health (SOH)	Neural Networks (NN), ANN	Extends battery life and improves performance
Driving Behavior Analysis	Analyze driver habits and vehicle usage patterns	ANN, CART, GBDT	Supports efficient driving and energy savings
Load Forecasting	Predict electricity demand for EV charging	MLR, ANN, LightGBM	Improves smart grid and charging station management
Intelligent Charging	Optimize charging schedules and charging rates	ANN, SVR, Reinforcement Learning	Reduces charging costs and grid congestion
Vehicle-to-Grid (V2G) Management	Manage energy exchange between EVs and the power grid	ANN, ML-based optimization	Enhances grid stability and renewable energy utilization
Fault Detection and Diagnostics	Detect battery, motor, and charging system faults	ANN, Decision Tree, ML classifiers	Improves safety and reduces maintenance costs
Route Optimization	Recommend energy-efficient routes	ANN, XGBoost, LightGBM	Minimizes energy consumption and travel time
Cybersecurity	Detect malicious activities and cyberattacks in EV systems	ML-based anomaly detection	Enhances security and system reliability

Multiple Linear Regression (MLR) is one of the machine learning methods most often used for EV range optimization because it helps identify how different driving factors affect the vehicle's remaining range. Artificial Neural Networks (ANNs) have also become widely used, mainly because they can learn complex patterns from large datasets and make accurate predictions about battery performance, energy consumption, and driving range. More advanced techniques, such as Gradient Boosting Decision Trees (GBDT) and LightGBM, can improve prediction accuracy even further, especially under complex driving conditions and when working with large amounts of EV data.

Machine learning models can take into account many different factors, including battery State of Charge (SOC), temperature, traffic conditions, vehicle speed, road slope, and driving behavior, to produce more dependable predictions. This allows intelligent ML-based systems to improve range estimation, support longer battery life, optimize charging operations, and increase overall vehicle efficiency. Because of these benefits, machine learning has become an important technology in modern electric vehicles, helping with energy management, battery health monitoring, smart charging, and even cybersecurity. By supporting data-driven decisions, ML improves EV performance, strengthens reliability, and increases user confidence, all of which encourage the wider adoption of smart and sustainable transportation systems [34].

Future Scope:

The future of the electric vehicle (EV) industry looks very promising, supported by ongoing progress in battery technology, charging infrastructure, and smart energy management. New developments such as solid-state batteries, ultra-fast charging, Vehicle-to-Grid (V2G) systems, and AI-based energy optimization are expected to improve EV performance, extend driving range, increase safety, and make vehicles more efficient overall. At the same time, government support, rising environmental awareness, and strong investment from major automobile manufacturers are helping speed up EV adoption around the world. In addition, the wider use of renewable energy, advances in autonomous driving, and the growth of shared electric mobility services are likely to create a transportation system that is cleaner, smarter, and more sustainable. As these trends continue, EVs are expected to play a leading role in transportation in the decades ahead.

Conclusion:

Electric vehicles are becoming an important part of sustainable transportation because they offer high efficiency, lower emissions, and reduced operating costs. This review examined different EV classifications, battery technologies, charging methods, charging infrastructure, and the main challenges involved in EV deployment. It also emphasized the growing importance of machine learning, smart energy management, energy trading, and cybersecurity in improving EV performance and reliability.

Although EVs still face challenges such as charging delays, limited infrastructure, grid integration issues, and security risks, ongoing progress in battery systems, fast-charging technology, and intelligent control methods is helping speed up their adoption. Looking ahead, further developments in smart charging, Vehicle-to-Grid (V2G) systems, and renewable energy integration are expected to play a major role in building electric mobility that is more efficient, secure, and sustainable.

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