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A COMPREHENSIVE LITERATURE REVIEW ON THE ADOPTION, TECHNOLOGICAL ADVANCEMENTS, AND POLICY FRAMEWORKS OF ELECTRIC VEHICLES

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ABSTRACT
This literature review explores the evolving landscape of electric vehicles (EVs), focusing on technological advancements, environmental implications, market trends, consumer adoption, and policy frameworks. The review synthesizes findings from recent academic and industry sources to highlight the rapid growth of EV technology, particularly in battery efficiency, charging infrastructure, and integration with renewable energy. It also examines the environmental benefits of EV adoption, including reduced greenhouse gas emissions and lower dependence on fossil fuels. Furthermore, the review analyzes consumer attitudes, behavioral factors influencing EV purchases, and cross-cultural variations in adoption rates. Government incentives and regulatory measures are evaluated for their role in promoting sustainable transportation. By providing a comprehensive overview of the current state of EV research this review identifies key challenges and opportunities, offering insights for researchers, policymakers, and industry stakeholders aiming to accelerate the global transition toward electric mobility.

KEY WORDS: *Consumer Adoption, Behavior, Electric Vehicles, Consumer, Trust.*

INTRODUCTION
Electric Vehicles (EVs) represent a transformative shift in the global transportation industry, offering a sustainable alternative to traditional internal combustion engine (ICE) vehicles. Powered by one or more electric motors and using energy stored in rechargeable batteries, EVs produce zero tailpipe emissions, thereby contributing to the reduction of greenhouse gases and air pollution.

The growing concerns over climate change, rising fuel prices, and depleting fossil fuel reserves have accelerated the adoption of EVs across the world. Technological advancements in battery efficiency, charging infrastructure, and government incentives have further boosted their popularity. EVs are broadly categorized into Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Hybrid Electric Vehicles (HEVs), each offering distinct advantages in terms of performance and environmental impact. Despite challenges such as limited driving range, charging infrastructure gaps, and higher initial costs, continuous innovation is paving the way for mass EV adoption. As nations strive to meet carbon neutrality goals, EVs are poised to play a central role in shaping a cleaner and more efficient future for transportation. Electric Vehicles (EVs) are rapidly emerging as a crucial solution to the global challenges of environmental degradation, energy security, and sustainable mobility. Unlike conventional vehicles that rely on internal combustion engines (ICEs) and burn fossil fuels, EVs are powered by electric motors using energy stored in batteries or other energy storage devices. This fundamental shift in propulsion technology significantly reduces air pollution, greenhouse gas emissions, and dependency on non-renewable energy sources. The concept of electric mobility is not new; early prototypes of EVs date back to the 19th century. However, due to limited battery technology and the dominance of gasoline-powered vehicles, their development remained stagnant for decades. It is only in the past two decades that EVs have gained renewed interest due to increasing concerns about climate change, oil price volatility, urban air quality, and the need for sustainable development. Advances in lithium-ion batteries, fast-charging infrastructure, and supportive government policies have accelerated the growth and adoption of EVs worldwide.

Types of electric vehicle:-
Battery Electric Vehicles (BEVs): Fully electric vehicles powered solely by rechargeable batteries.
Plug-in Hybrid Electric Vehicles (PHEVs): Vehicles with both an internal combustion engine and an electric motor that can be recharged from an external power source.
Hybrid Electric Vehicles (HEVs): Vehicles that combine a conventional engine with an electric propulsion system, but cannot be plugged in.

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Governments around the world are promoting EV adoption through subsidies, tax incentives, stricter emission norms, and infrastructure development. Leading automobile manufacturers are investing heavily in EV research, production, an d innovation to meet the growing consumer demand and regulatory requirements. Despite their numerous benefits, EVs face challenges such as high upfront costs, limited driving range, battery recycling issues, and the need for extensive charging infrastructure. However, ongoing research and innovation in battery technology, energy management systems, and vehicle design are expected to overcome these barriers in the near future.

Features of Electric Vehicle

1. Electric Powertrain:-Powered by an electric motor instead of a conventional internal combustion engine (ICE).Uses energy stored in rechargeable batteries.
2. Battery Pack:-Usually lithium-ion batteries. Rechargeable via standard or fast-charging stations. Battery capacity (measured in kWh) determines the vehicle's driving range.
3. Zero Tailpipe Emissions:-No exhaust gases like CO_2, NOx or particulates. Environmentally friendly and contributes to reduced air pollution.
4. Regenerative Braking:-Converts kinetic energy from braking back into electrical energy. Increases energy efficiency and battery range.
5. Quiet Operation:-Minimal noise and vibration compared to gasoline/diesel engines. Enhances driving comfort, especially in urban areas.
6. Lower Maintenance:-Fewer moving parts than traditional vehicles. No oil changes, spark plugs, or exhaust system maintenance.
7. Advanced Technology Integration:-Digital dashboards, smart infotainment systems. Often equipped with remote monitoring, smartphone apps, and OTA (Over-The-Air) software updates.
8. Multiple Charging Options:-Home charging (Level 1 or Level 2).Public fast charging (DC Fast Charging).Wireless (inductive) charging in some models.

OBJECTIVES OF THE STUDY

The development and promotion of electric vehicles aim to address a wide range of environmental, economic, and technological challenges associated with conventional transportation. The key objectives of electric vehicles include:

1. To understand how EV range has improved due to advancements in battery technology, vehicle design, and energy management systems.
2. To understand how the availability of fast-charging and home-charging options affects user behavior and range confidence.
3. To point out gaps in existing studies, such as the lack of long-term real-world data or regional variations in range performance.

REVIEW OF LITERATURE

SL.NO	Field of Research	Focus	Outcomes	Reference
1	Hybrid Vehicle; A Study on Technology	This study says that Hybrid Electric Vehicle is considered as the most industrially matured technology and has efficiency.	At lower speeds, no smog is emitted maintaining its sustainable advantage. Till lower speed, the car runs on the electric motor and on cruising speed, it runs on IC engine.	Prajapati C Karan , Patel Ravi and Sagar Rachit(2014)
2	Quantifying the Societal Benefits of Electric Vehicles	This study is focusing on how electric vehicle are beneficial to the society.	Results from this study says that tool for policymakers to use in determining appropriate investment and incentive levels for electric vehicles.	Malmgren Ingrid (2016)
3	Electric vehicles and India's low carbon passenger transport: A	This study covers usage of low carbon in electric vehicle.	The finding says that clean trans port portfolio of the future which can concurrently	S Dhar, M Pathak, & Shukla(2016)

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	long-term co-benefits assessment		deliver low carbon as well as energy security and air quality co-benefits india.	
4	Electric vehicles in India and its impact on grid	This study covers the challenges of EV proliferation, its impact on grid and glimpses of Singapore, Amsterdam policy for EV	Findings says that Adequate capacity addition primarily through Renewables in distribution grid in order to meet additional demand created by high penetration of EVs.	- PMU NSGM-(2017)
5	Electric vehicle life cycle analysis and raw material availability	The demand and availability of critical raw materials (such as lithium, cobalt, nickel, graphite, and rare earths) used in batteries and electric motors. There can be expected to be a massive increase in demand arising from a growth in electric vehicles	Resources of critical metals and rare earth minerals will not be constrained in the coming decades and won't stop the EV transition, as some have argued.	Environment and Transport (2017)
6	Electric Vehicle Life Cycle Cost Analysis	Develop a life cycle cost (LCC) model for automotive vehicles that accurately evaluates electric vehicle types.	The vehicles considered are hybrid, plug-in hybrid and battery-electric vehicles, as compared to ICEs using gasoline, ethanol, or diesel.	Raustad Richard (2017)
7	Health Management System for Lithium-Ion Batteries of Electric Vehicles	This study focus on Lithium-ion batteries (LIBs) are one of the most promising technologies.	Finding says that makes research in battery health management a worthy area of future research.	Omariba Bosire Zachary ,ID Zhang Lijun and Et.al., (2018)
8	Electric vehicles	This study focused on past present and future electric vehicle.	Findings gives clear picture regarding electric vehicle.	Chan C C(2020)
9	Wireless charging of electric vehicle: a review	The main agenda of this paper is to give an overview of various wireless charging techniques out of which inductive wireless transfer has proven to be the best method of wireless charging.	The electric vehicle batteries which were to take quite a lot time to charge up to the rated value will be charged within less time comparatively as their battery capacity is reduced.	D Abinand , M Deepak and Et.al.,(2020)
10	A Detailed Study on Electric Vehicles	EVs are preferred by the majority of the people as an EV does	. The future of electric vehicles completely depends on the	Patel Mukesh (2021)

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		not contribute to noise pollution, easy to operate, does not have the fuel costs associated with conventional vehicles and as an urban vehicle, it is highly useful.	changes made in batteries in the future. As of today, there are electric vehicles available in market, but there are some disadvantages which needs to be improved in future	
11	Comparison of Batteries Used in Electrical Vehicles	This study focused on batteries used in electrical vehicles	Li-ion battery becomes the most popular power supply for EVs. Li-ion battery is significantly better than other types of battery, Lithium-ion battery has obvious advantages such as a long cycle life.	Muslimin Selamat, Nawawi Zainuddin , and Et.al.,(2021)
12	Design And Analysis of Powertrain for Electric Vehicle	This study tells regarding design and anaylsis of electric vehicle	Finding tells detailed information regarding powertrain electric vehicle.	Mali Aniket Shukla Abhishek and Et.al.,(2021)
13	Factors influencing adoption of electric vehicles	This study would give an insight to the Indian market's perception of EV adoption and identifying the potential factors that influence the Electric Vehicle Adoption.	Findings shows that E-mobility, it is mandatory to address the knowledge gap as lack of awareness of potential barriers in EV adoption. As a limited study has been conducted in this field in India, identifying and classifying these barriers into various groups is necessary.	K.V Sriram , Kenneth Lidwin &Et.al.,(2022)
14	The economics of electric vehicles	This study focused on private and public economics of electric vehicles (EVs) and discuss when market forces will produce the optimal path of EV adoption.	Finding says that In an economy with scarce resources and a vast array of policy objectives, policymakers should seek to identify ways to deploy public resources that maximize net benefits, which requires avoiding the creation of conflicting incentives.	Rapson S David, Muehlegger Erich (2022)
15	Critical Analysis of the Electric Vehicle Industry: Five forces	In this study critical analysis of electric vehicle has done by considering porter's	The finding says that industry-based perspective brings forth the profitability	Fedotov Pavel (2022)

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	and strategic action fields	five forces and strategies.	obstacles within the industry as well as provides a general overview of the socio political trends in the competitive environment.	
16	Assessment of light-duty electric vehicle costs and consumer benefits in the united states in the 2022–2035 time frame	This study analyzes battery and electric vehicle manufacturing costs in the 2022–2035 time frame and compares them with the costs for manufacturing conventional gasoline vehicles.	Battery electric vehicle purchase price parity is coming before 2030 for BEVs with up to 300 miles of range across all light-duty vehicle classes.	Slowik, Peter, Isenstadt, Aaron , and Et.al.,(2022)
17	Electric Vehicles: Benefits, Challenges, and Potential Solutions for Widespread Adaptation	This study is focusing benefits of using electric vehicle and challenges in adaptation of electric vehicle	Findings says that supportive policies and regulations, investment in charging infrastructure, and public education and outreach initiatives will help in adaptation.	Alanazi Fayez (2023)
18	The Impacts of Popularization of Electric Vehicles on Urban Air Pollution	This study is mainly focusing on air pollution in urban area.	This study investigates the potential benefits and challenges of popularizing electric vehicles on urban air pollution and the vehicle industry.	Chen Yanlin (2023)
19	Wireless Power Transfer for Electric Vehicle	Design and analysis of coil system with helix and spiral coil and with different shapes for the magnetic core to evaluate their inductive characteristics.	Here it is found that electric vehicle futher can be used as wireless power transfer.	Mude Naik Kishore (2023)
20	Literature Review Of Electric Vehicle And Its Impact On The Distribution System	The research helped us examine the different methodologies designed by people to reduce this impact on the distribution system and developing a technology which can find an appropriate solution to the problems faced due to EV's	This paper has provided readers with a comprehensive understanding of all the aforementioned concepts, equipping them with a profound familiarity with the pertinent research domains.	Mahala Vikas, Mutreja Mansi (2023)

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21	Enablers of Electric Vehicles Adoption in India	This study focused on reasons to adopt electric vehicle in India	Finding says that Electric vehicles in India are gaining ground with the support of the Indian government.	Pandita Deepika, Bhatt Vimal, and Et.al.,(2023)
22	Wireless Charging Of Electric Vehicle While Driving	This paper provides a comprehensive review of the current state of research on dynamic charging of electric vehicles by IWPT, including the various approaches that have been proposed, technical challenges, and potential applications.	The research aims to study high power transfer efficiency, safety, and minimal EMI while maintaining compatibility with existing charging infrastructure.	Shinde Nikhil Ashok and Et.al.,(2023)
23	The future of European electric vehicles	This study is focused on electric vehicle beneficial to European in future.	The findings says that future depends on how well European policymakers and corporations are able to develop and safeguard European EV manufacturing capabilities in competition and cooperation with foreign producers.	Wieringen van Kjeld (2024)
24	Electric Vehicles in India: A Five-Year Performance Analysis	This study focused on The automotive landscape in India has been undergoing a significant transformation over the last five years, marked by the growing presence and adoption of electric vehicles (EVs).	The growth of electric vehicles (EVs) in India is on an upward trajectory, underpinned by a combination of government incentives, increasing environmental awareness, expanding charging infrastructure, and automaker investments.	Bhut Aayush (2024)
25	Solar Powered Wireless Electric Vehicle (EV) Charging System	This study Develop a solar-powered charging infrastructure for electric vehicles. Implement wireless charging technology for seamless charging experiences.	The Solar Powered Wireless Electric Vehicle (EV) Charging System offers a transformative solution at the intersection of renewable energy and transportation innovation.	Asst. Prof. Palorkar Triveni, Tiwari Ankita and Et.al.,(2024)
26	Estimating the longevity of electric vehicles	An accurate measure of the longevity of different powertrains,	Technological advances, supportive policies, and increasing	Tien Viet Nguyen- ,J.RRobert ,. and Et.al.,(2024)

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		whether the lifetime is measured in time or distance.	concern for the environment have driven the shift from traditional internal combustion engines towards cleaner powertrains, paving the way towards a net-zero carbon future.	
27	Electrical vehicle wireless charging system using solar panel	This study focused on The increasing adoption of electric vehicles (EVs) represents a significant milestone in the transition to a cleaner and more sustainable mode of transportation	The electric vehicle charging wirelessly reduces the need for a transmission line and reduces energy consumption, making it a simple and more practical way	Prof. Jambhale U.S. , Gade Sanjay Akshada and Et.al.,(2024)
28	The Future of Sustainable Transportation: A Comprehensive Study of Electric Vehicle Adoption and Its Impact on Global Carbon Emissions	This study focus on eco-friendly transportation systems and An encouraging step towards lowering transportation's carbon footprint is the broad use of electric vehicles (EVs).	Findings indicates that Although EV adoption is still in its infancy, the technology has enormous promise for drastically cutting down on the world's carbon emissions.	Singh Kumar Dr. Ranjeet (2025)
29	Consumer Perception Towards E-Vehicles	The global shift towards sustainable transportation has gained significant momentum as a response to the pressing challenges of climate change, environmental degradation, and fossil fuel dependency.	Its provided information regarding the consumer preferences, the factors driving the consumers to purchase e vehicles, Government schemes and incentives for e-vehicles. It helped in analysing the satisfaction level of e-vehicle users.	Murali(Neethu 2025)
30	Barriers to Widespread Electric Vehicle Adoption: Consumer Perception and Policy Implications	This study is focusing on policy and implication towards Electric Vehicle	The findings says that more sustainable transportation system that benefits customers and the earth can be achieved if society can overcome the obstacles associated with electric vehicle technology and infrastructure.	Kher Dr. Alpana (2025)

FINDINGS

- Significant progress has been made in battery technologies, especially lithium-ion batteries, which offer higher energy density, faster charging, and longer lifespan.
- Wireless and solar-powered charging systems are emerging as innovative solutions for range and convenience enhancement.

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- Vehicle powertrain design, regenerative braking, and integrated smart technologies are improving EV efficiency and performance
- EVs contribute to reductions in greenhouse gas emissions, air pollution, and noise levels, supporting global climate goals.
- Studies confirm EVs can positively impact urban air quality, with significant long-term health and societal benefits.
- EV adoption aligns with energy security and sustainability strategies, especially for developing countries like India.
- Key challenges include high upfront costs, limited charging infrastructure, battery recycling issues, and range anxiety.
- Consumer hesitation often stems from lack of awareness, inadequate policy communication, and uncertain long-term reliability.
- Subsidies, tax incentives, and emission regulations play a crucial role in encouraging adoption.
- India's government is actively supporting EV growth through FAME policies, infrastructure development, and manufacturer incentives.
- Global case studies (Singapore, Amsterdam, EU) emphasize the need for strategic public-private partnership
- Adoption is strongly influenced by consumer knowledge, incentives, brand trust, and perceived value.
- Cultural and regional factors significantly affect buying decisions and adoption rates across countries.
- Studies project that price parity between EVs and ICE vehicles, especially BEVs with up to 300 miles range, could be achieved before 20

SUGGESTIONS

- Expand and sustain government incentives (e.g., subsidies, tax rebates, lower registration fees) to boost adoption, particularly in emerging markets like India.
- Enforce nationwide EV-friendly policies such as mandatory EV quotas for automakers, zoning regulations for charging stations, and stricter emission norms for ICE vehicles.
- Introduce standardized policy frameworks across states to ensure uniform EV ecosystem development
- Encourage public-private partnerships (PPPs) to install fast-charging stations across urban, suburban, and rural areas.
- Promote smart charging and grid integration systems to prevent overloading local power infrastructure.
- Prioritize wireless and solar-based charging research for flexible, off-grid, and renewable-powered solution
- Launch targeted awareness campaigns to dispel myths about EV range, maintenance, and safety.
- Provide transparent comparisons between ICE vehicles and EVs in terms of cost, benefits, and emissions.
- Support community test drives and experiential learning programs to build public confidence.

CONCLUSION

The comprehensive literature review underscores that electric vehicles (EVs) are at the forefront of the global transition toward sustainable and low-carbon transportation. With technological innovations, particularly in battery efficiency, wireless charging, and intelligent vehicle systems, EVs are increasingly becoming a viable alternative to internal combustion engine (ICE) vehicles. Moreover, the environmental advantages of EVs such as reduced greenhouse gas emissions, improved air quality, and decreased fossil fuel dependency position them as key contributors to climate change mitigation efforts.

The Indian context, in particular, presents unique opportunities and challenges. With its growing urban population, energy security concerns, and strong policy interest in clean mobility, India stands at a critical juncture. Bridging the gap between policy intentions and practical implementation will be crucial. Additionally, the need for domestic battery manufacturing, robust recycling systems, and skilled human capital is increasingly evident.

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