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Barriers Against the Use of EV-Review

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Abstract: The transition toward electric vehicles (EVs) is widely recognized as a crucial step in reducing greenhouse gas emissions and promoting sustainable transportation. Despite continuous advancements in technology and increasing policy support, the adoption rate of EVs remains slower than expected, particularly in developing economies. This paper presents a systematic review of existing literature to identify and analyze the major barriers limiting EV adoption.The study synthesizes findings from empirical, analytical, and modeling-based research and categorizes the barriers into five key dimensions: economic, technical, infrastructural, policy and regulatory, and behavioral. The review highlights that high initial costs, limited charging infrastructure, range anxiety, policy inconsistencies, and lack of consumer awareness are among the most critical challenges. Furthermore, these barriers are highly interconnected and vary across regions. By providing a consolidated and structured understanding of EV adoption challenges, this study offers valuable insights for policymakers, researchers, and industry stakeholders to design effective strategies that can accelerate the transition toward sustainable electric mobility.

Keywords: Electric Vehicles, EV Adoption, Charging Infrastructure, Sustainable Transportation, Systematic Review, Adoption Barriers

I. INTRODUCTION

The transportation sector is one of the largest contributors to global carbon emissions and environmental degradation. Rapid urbanization, increasing vehicle ownership, and heavy reliance on fossil fuels have intensified environmental concerns, making sustainable mobility solutions a global priority. In this context, electric vehicles (EVs) have emerged as a promising alternative to conventional internal combustion engine vehicles.EVs offer several advantages, including reduced greenhouse gas emissions, improved energy efficiency, and lower operating costs over time. Governments across the world are actively promoting EV adoption through subsidies, tax incentives, and investments in charging infrastructure. Technological advancements in battery systems, power electronics, and energy management have further improved the feasibility and performance of EVs.However, despite these positive developments, the adoption of EVs has not reached the expected scale. This gap between technological readiness and actual adoption indicates the presence of multiple barriers that go beyond engineering challenges. These barriers include financial constraints, infrastructure limitations, policy uncertainties, and behavioral resistance.

Previous studies have examined these challenges individually. For instance, Adhikari et al. [1] highlighted cost and infrastructure limitations, while Pamidimukkala et al. [2] emphasized behavioral and financial risk factors. Tarei et al. [3] and Gupta et al. [4] focused on challenges in developing economies, particularly India. However, the findings remain fragmented across different studies and regions. Therefore, this paper aims to provide a systematic and integrated review of EV adoption barriers by synthesizing existing research and presenting a unified framework for understanding these challenges.

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II. LITERATURE REVIEW

Sr. No.	Author(s)	Year	Methodology	Key Findings	Research Limitations
1	Adhikari et al. [1]	2020	Analytical Study	High cost, limited infrastructure, low awareness	Limited behavioral analysis
2	Pamidimukkala et al. [2]	2023	SEM	Financial risk, charging access, policy influence	Focus on intention only
3	Tarei et al. [3]	2020	Empirical	Cost, policy gaps, infrastructure issues	Limited global scope
4	Gupta et al. [4]	2020	Analytical Framework	Battery concerns, awareness issues	Focus on BOEVs
5	Manjula et al. [5]	2021	Survey	Cost barriers, hesitation	Limited modeling
6	Rezvani et al. [6]	2015	Literature Review	Consumer perception, behavioral barriers	Conceptual
7	Hardman et al. [7]	2017	Empirical	Role of incentives in adoption	Region-specific
8	Li et al. [8]	2017	Review	Policy & infrastructure importance	Limited developing country focus
9	Egbue & Long [9]	2012	Survey	Range anxiety, cost issues	Small sample
10	Sierzchula et al. [10]	2014	Cross-country Analysis	Infrastructure & incentives drive adoption	Macro-level only
11	Axsen & Kurani [11]	2013	Behavioral Study	Consumer preference varies by vehicle type	Limited scalability
12	Carley et al. [12]	2013	Survey	Income, awareness influence adoption	US-focused
13	Helveston et al. [13]	2015	Comparative Study	Subsidies impact adoption significantly	Regional bias
14	Gnann et al. [14]	2018	Modeling	Market potential depends on cost reduction	Assumption-based
15	Jansson et al. [15]	2017	Behavioral Analysis	Environmental concern drives adoption	Limited technical factors
16	Wang et al. [16]	2018	Policy Analysis	Incentive policies improve adoption	Country-specific
17	Breetz & Salon [17]	2018	Policy Study	Subsidies are essential for early adoption	Short-term focus
18	Sovacool et al. [18]	2019	Social Analysis	Social acceptance affects EV diffusion	Qualitative bias
19	Noel et al. [19]	2019	Book/Review	Multi-dimensional EV transition challenges	Broad scope
20	Kumar & Alok [20]	2020	Literature Review	Identifies economic & behavioral barriers	Secondary data
21	Singh et al. [21]	2021	Empirical	Infrastructure & cost major barriers in India	Limited sample
22	Sharma et al. [22]	2022	Analytical	Challenges & opportunities in India	Generalized findings
23	IEA [23]	2023	Report	Global EV growth trends & barriers	Macro-level data

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Sr. No.	Author(s)	Year	Methodology	Key Findings	Research Limitations
24	NITI Aayog [24]	2022	Policy Report	India-specific EV challenges	Policy-focused only
25	IRENA [25]	2023	Technical Report	Technology & deployment barriers	Less behavioral focus
26	Rogers [26]	2003	Theoretical Model	Innovation adoption theory	Not EV-specific

III. METHODOLOGY

This study employs a systematic literature review methodology to identify, classify, and analyze the major barriers restricting the adoption of electric vehicles (EVs). The methodological framework is designed to synthesize empirical findings and analytical insights from existing scholarly research and to develop a structured categorization of EV adoption barriers.

A. Research Design

A qualitative and analytical review approach was adopted to examine published studies that investigate factors influencing EV adoption. The review focuses on peer-reviewed journal articles and conference proceedings that analyze economic, technical, infrastructural, policy-related, and behavioral constraints. Key studies considered in this review include Adhikari et al. [1], Pamidimukkala et al. [2], Tarei et al. [3], Gupta et al. [4], Manjula et al. [5], and related structural modeling research [6].

These studies were selected because they employ diverse methodologies, including analytical reviews, survey-based research, and structural equation modeling (SEM), which provide quantitative and qualitative perspectives on EV adoption barriers.

B. Literature Selection Criteria

The selection of literature was guided by the following inclusion criteria:

1. The study must explicitly examine barriers or constraints affecting EV adoption.
2. The research must employ empirical analysis, survey-based methods, analytical frameworks, or structural modeling techniques.
3. The study must be published in peer-reviewed journals or recognized academic conference proceedings.
4. The identified barriers must be clearly categorized or measurable.

Studies that focused solely on vehicle design, battery chemistry, or engineering performance without addressing adoption challenges were excluded from the review.

C. Data Extraction Process

For each selected study, relevant information was systematically extracted, including:

- Research objective and scope
- Methodology employed (e.g., SEM analysis in [2], empirical analysis in [3])
- Geographic focus
- Key barriers identified
- Major findings and limitations

For instance, Adhikari et al. [1] emphasized structural and economic barriers such as high purchase costs and limited infrastructure. Pamidimukkala et al. [2] identified perceived financial risk and charging accessibility as significant

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predictors of consumer intention. Tarei et al. [3] and Gupta et al. [4] highlighted infrastructure deficiencies and policy implementation gaps in emerging economies. Manjula et al. [5] reported cost sensitivity and consumer hesitation as primary constraints.

D. Barrier Classification Framework

Based on comparative synthesis of the reviewed literature, the identified barriers were organized into five major categories:

1. **Economic Barriers:** High upfront vehicle cost, battery replacement expenses, financial risk perception [1], [2].
2. **Technical Barriers:** Range anxiety, long charging time, battery durability concerns [3], [4].
3. **Infrastructure Barriers:** Limited charging stations and uneven network distribution [1], [3].
4. **Policy and Regulatory Barriers:** Inconsistent incentives, lack of long-term regulatory clarity [3], [4].
5. **Behavioral and Social Barriers:** Low consumer awareness, resistance to change, perceived reliability risks [2], [5], [6].

This classification enables a structured comparison of barriers across different regional and methodological contexts.

E. Analytical Synthesis

The final stage of the methodology involved synthesizing findings across studies to:

- Identify recurring and dominant barriers
- Compare results across developed and developing economies
- Evaluate methodological differences among prior research
- Highlight gaps requiring further investigation

Unlike primary empirical research, this study consolidates fragmented findings from multiple investigations into a unified analytical framework. This structured synthesis supports a comprehensive understanding of the multidimensional barriers limiting EV adoption.

IV. CLASSIFICATION AND ANALYSIS OF BARRIERS

The systematic review of selected literature reveals that barriers to electric vehicle (EV) adoption are multidimensional and interrelated. Based on comparative analysis of the reviewed studies [1]– [6], the identified barriers are categorized into five major dimensions: economic, technical, infrastructural, policy and regulatory, and behavioral barriers. Each category is discussed in detail below.

A. Economic Barriers

Economic constraints are among the most frequently reported barriers limiting EV adoption. High initial purchase cost remains a dominant concern across both developed and developing markets. Adhikari et al. [1] identified vehicle price as a primary deterrent, particularly in regions with limited financial incentives. Similarly, Pamidimukkala et al. [2] found that perceived financial risk significantly influences consumer intention to adopt EVs.

Battery replacement cost further contributes to economic uncertainty. Gupta et al. [4] emphasized that concerns regarding battery durability and replacement expenses reduce consumer confidence, especially in emerging economies. Tarei et al. [3] also reported that inadequate subsidy structures and inconsistent incentive programs increase cost sensitivity among potential buyers.

Thus, economic barriers primarily include:

- High upfront vehicle cost
- Battery replacement and maintenance cost

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- Limited access to financial incentives
- Perceived financial risk

These factors collectively reduce affordability and slow market penetration.

B. Technical Barriers

Technical limitations significantly affect consumer perception and practical usability of EVs. One of the most prominent issues is range anxiety, defined as the fear of battery depletion before reaching a charging station. Studies such as [3] and [4] indicate that limited driving range remains a critical psychological and functional concern.

Charging time is another technical limitation. Compared to conventional refueling, EV charging requires longer durations, which may discourage adoption, particularly for long-distance travel. Battery degradation and uncertainty regarding long-term performance were also highlighted as important technical concerns in [4].

Therefore, technical barriers include:

- Limited driving range
- Long charging duration
- Battery degradation concerns
- Performance uncertainty

These limitations affect both consumer confidence and operational feasibility.

C. Infrastructure Barriers

Infrastructure readiness plays a crucial role in EV adoption. A lack of sufficient public charging stations is consistently reported as a major constraint. Adhikari et al. [1] emphasized that inadequate charging infrastructure restricts accessibility and increases user inconvenience. Similarly, Tarei et al. [3] identified uneven distribution of charging stations as a critical barrier in developing countries.

The absence of fast-charging facilities and limited rural coverage further exacerbate accessibility concerns. Pamidimukkala et al. [2] demonstrated that charging accessibility significantly influences consumer adoption intentions.

Infrastructure barriers primarily include:

- Insufficient charging stations
- Uneven geographic distribution
- Limited fast-charging facilities
- Weak grid and institutional support

Without robust infrastructure development, large-scale EV diffusion remains constrained.

D. Policy and Regulatory Barriers

Government policies significantly influence EV market growth. However, inconsistent regulatory frameworks and lack of long-term policy clarity hinder adoption. Tarei et al. [3] reported that policy uncertainty discourages investment and consumer confidence. Gupta et al. [4] also emphasized the need for stronger institutional coordination and stable incentive programs.

In many developing economies, weak implementation of EV policies and limited public-private collaboration further restrict infrastructure expansion and consumer trust.

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Policy-related barriers include:

- Inconsistent or short-term incentives
- Lack of standardized regulations
- Weak institutional coordination
- Unclear long-term EV roadmap

Effective regulatory frameworks are therefore essential to ensure sustained EV market growth.

E. Behavioral and Social Barriers

Behavioral and psychological factors play a significant role in adoption decisions. Pamidimukkala et al. [2] utilized structural equation modeling to demonstrate that perceived risk and consumer attitudes strongly influence adoption intention. Manjula et al. [5] identified consumer hesitation and limited awareness as critical social barriers.

Resistance to technological change, lack of trust in new systems, and limited knowledge about EV benefits further contribute to adoption delays [6]. These behavioral factors often interact with economic and infrastructural constraints, amplifying overall resistance.

Behavioral barriers include:

- Low consumer awareness
- Risk perception and uncertainty
- Resistance to technological change
- Social influence factors

Addressing these barriers requires targeted awareness campaigns and trust-building measures.

F. Comparative Insights

The review indicates that economic and infrastructure barriers are dominant in developing economies, whereas behavioral and financial risk perceptions are more prominent in developed markets [1]–[4]. Additionally, these barriers are interdependent; for example, limited infrastructure intensifies range anxiety, while policy uncertainty increases financial risk perception.

Thus, overcoming EV adoption challenges requires a multidimensional strategy integrating financial support, technological improvement, infrastructure expansion, regulatory stability, and consumer awareness initiatives.

V. DISCUSSION

The systematic review of existing literature indicates that barriers to electric vehicle (EV) adoption are not isolated factors but interconnected constraints that collectively influence consumer behavior and market growth. The reviewed studies [1]–[6] consistently demonstrate that economic, technical, infrastructural, regulatory, and behavioral barriers operate simultaneously, and their relative impact varies across regions.One of the most dominant findings across the literature is the persistent influence of economic barriers. High initial vehicle cost and perceived financial risk remain critical deterrents to EV adoption [1], [2]. While developed economies may partially offset these concerns through subsidies and tax incentives, developing countries continue to experience stronger cost sensitivity due to income disparities and inconsistent financial support mechanisms [3], [4]. This suggests that economic barriers are foundational and often amplify other adoption challenges.

Infrastructure availability is another decisive factor. Limited charging station networks and uneven geographic distribution significantly contribute to range anxiety and user inconvenience [1], [3]. The structural equation modeling approach used in [2] further confirms that charging accessibility directly influences consumer intention. These findings highlight the interdependency between technical and infrastructural barriers, as limited infrastructure intensifies perceived technical limitations such as range constraints and charging delays.Technical concerns, including battery

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durability and long charging duration, continue to affect consumer trust in EV reliability [3], [4]. Although technological advancements have improved battery performance, consumer perception often lags actual technical progress. This gap between technological capability and public confidence underscores the importance of awareness and education initiatives.

Policy and regulatory frameworks play a critical enabling role in EV adoption. Studies focusing on emerging economies [3], [4] emphasize that inconsistent policy implementation and lack of long-term strategic clarity discourage both consumer investment and infrastructure development. Without stable regulatory support, market growth remains uncertain, and private sector participation is limited. Therefore, policy barriers not only directly affect adoption but also indirectly influence economic and infrastructural constraints.Behavioral and psychological factors further complicate adoption dynamics. As demonstrated in [2] and [5], consumer attitudes, perceived risk, and resistance to technological change significantly influence adoption intention. Even in scenarios where economic and infrastructural conditions improve, negative perception and lack of awareness may still slow market penetration. These findings suggest that social acceptance and trust-building measures are as essential as financial incentives.

A comparative perspective reveals that developing countries tend to experience stronger infrastructure and policy-related barriers, while developed nations may face more perception-driven and behavioral challenges [1]–[4]. This regional variation indicates that a universal policy approach may not be effective; instead, context-specific strategies are required. Overall, the reviewed literature demonstrates that EV adoption barriers are multidimensional and mutually reinforcing. Addressing a single barrier in isolation may not produce substantial market growth. A coordinated strategy integrating financial incentives, infrastructure expansion, technological advancement, regulatory stability, and consumer awareness programs is necessary to accelerate EV diffusion globally.

VI. CONCLUSION AND FUTURE SCOPE

This study presented a systematic review of existing literature to identify and analyze the major barriers restricting the adoption of electric vehicles (EVs). Based on a structured synthesis of empirical and analytical studies [1]–[6], the barriers were classified into five primary dimensions: economic, technical, infrastructural, policy and regulatory, and behavioral factors.The review findings indicate that economic constraints—particularly high initial purchase cost and perceived financial risk—remain the most dominant barrier across regions [1], [2]. In developing economies, inadequate financial incentives and cost sensitivity further intensify adoption challenges [3], [4]. Infrastructure limitations, especially insufficient and unevenly distributed charging stations, significantly contribute to range anxiety and reduce consumer confidence [1], [3].Technical concerns such as limited driving range, long charging duration, and battery durability also affect adoption decisions, particularly in emerging markets [3], [4]. Additionally, policy instability and lack of long-term regulatory clarity hinder both private investment and consumer trust [3]. Behavioral factors—including low awareness, resistance to technological change, and perceived reliability risks—further influence consumer adoption intention [2], [5], [6].The review highlights that these barriers are interdependent and mutually reinforcing. Addressing a single constraint in isolation is unlikely to result in substantial EV market growth. A coordinated strategy integrating financial incentives, infrastructure development, regulatory stability, technological advancement, and public awareness initiatives is necessary to accelerate large-scale EV diffusion.

Although substantial research has been conducted on EV adoption barriers, several areas require further investigation. future research should focus on developing integrated quantitative models that simultaneously evaluate economic, behavioral, and infrastructural variables. While structural equation modeling approaches such as those used in [2] provide valuable insights, broader multi-country comparative studies are needed. longitudinal studies examining changes in consumer perception over time would help assess how technological advancements and policy interventions influence adoption behavior. Many existing studies, including [1] and [5], are cross-sectional and may not capture evolving market dynamics. further research is required to analyze the impact of large-scale infrastructure deployment on reducing range anxiety and behavioral resistance. Empirical evaluation of charging network expansion strategies would strengthen policy formulation [3]. Greater emphasis should be placed on examining the interaction between regulatory frameworks and private sector participation. Stable long-term policies may significantly influence investment decisions and infrastructure growth [4]. future studies may explore region-specific strategies for overcoming adoption barriers, particularly in developing economies where economic and institutional challenges remain prominent [3], [4]. Comparative global analyses can support the formulation of context-sensitive EV promotion strategies. Overall, continued interdisciplinary research integrating engineering, economic, and behavioral perspectives is essential to overcome existing barriers and ensure a sustainable transition toward electric mobility.

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