© Volume 2, Issue 11, November 2026 | JATIR
e-ISSN: 2839-5786, p-ISSN: 3139-8464

Environmental Impact of Transition from Ice (Internal Combustion Engine) Vehicles to Electric Vehicles in India

[1]Pushparaj Tiwari, [2]Arundhati Singh
[1]*Department of Environmental Science, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, 273009, U.P.,India.*
[2]*Department of Zoology, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, 273009, U.P.,India.*

***Abstract*—The transportation sector is one of the major contributors to environmental pollution and climate change in India, primarily due to the extensive use of Internal Combustion Engine (ICE) vehicles. These vehicles emit significant amounts of greenhouse gases such as carbon dioxide (CO_2), along with harmful air pollutants like nitrogen oxides (NOx) and particulate matter (PM2.5), which adversely affect air quality and public health. This study aims to analyze the environmental impact of the transition from ICE vehicles to Electric Vehicles (EVs) in India. The research is based on a mixed-method approach, incorporating both primary data (survey-based analysis) and secondary data obtained from government reports and international agencies such as NITI Aayog, CPCB, and IEA. The results indicate that EVs have the potential to significantly reduce tailpipe emissions and improve urban air quality. However, the overall environmental benefits of EVs depend on factors such as the source of electricity generation and the environmental cost associated with battery manufacturing. While EVs may have higher emissions during the production phase, they tend to offset these emissions over their operational life cycle. The study concludes that the transition to Electric Vehicles can contribute substantially to environmental sustainability in India, provided it is supported by cleaner energy sources and effective battery management systems. Addressing challenges such as high initial costs, limited charging infrastructure, and public awareness is essential for accelerating EV adoption.**

I. INTRODUCTION

The increasing levels of environmental pollution and climate change have become major global concerns in recent decades. Among various contributing sectors, transportation is recognized as a significant source of greenhouse gas emissions and air pollutants. The extensive use of Internal Combustion Engine (ICE) vehicles has led to a rapid increase in emissions such as carbon dioxide

(CO_2), nitrogen oxides (NOx), and particulate matter (PM2.5), which have serious implications for both environmental sustainability and human health.

In India, the situation is particularly critical due to rapid urbanization, population growth, and a sharp rise in the number of vehicles. Major cities are frequently experiencing poor air quality levels, with transportation being one of the key contributors. The dependence on fossil fuels in the transport sector further intensifies the problem, making it necessary to explore cleaner and more sustainable alternatives.

Therefore, it becomes important to study the environmental impact of the transition from ICE vehicles to Electric Vehicles, especially in the Indian context. This study focuses on understanding the potential benefits and challenges associated with this transition, providing insights into its role in achieving environmental sustainability. The transition from conventional ICE vehicles to Electric Vehicles is not only an environmental necessity but also an economic and technological shift. Governments across the world, including India, are introducing various policies and incentives to promote the adoption of EVs. Initiatives such as subsidies, tax benefits, and the development of charging infrastructure are being implemented to accelerate this transition. In addition, the growing awareness among people regarding climate change and environmental sustainability is encouraging a shift towards cleaner transportation alternatives (Fig.1). However, the success of this transition depends on multiple factors, including technological advancements, policy support, and public acceptance.

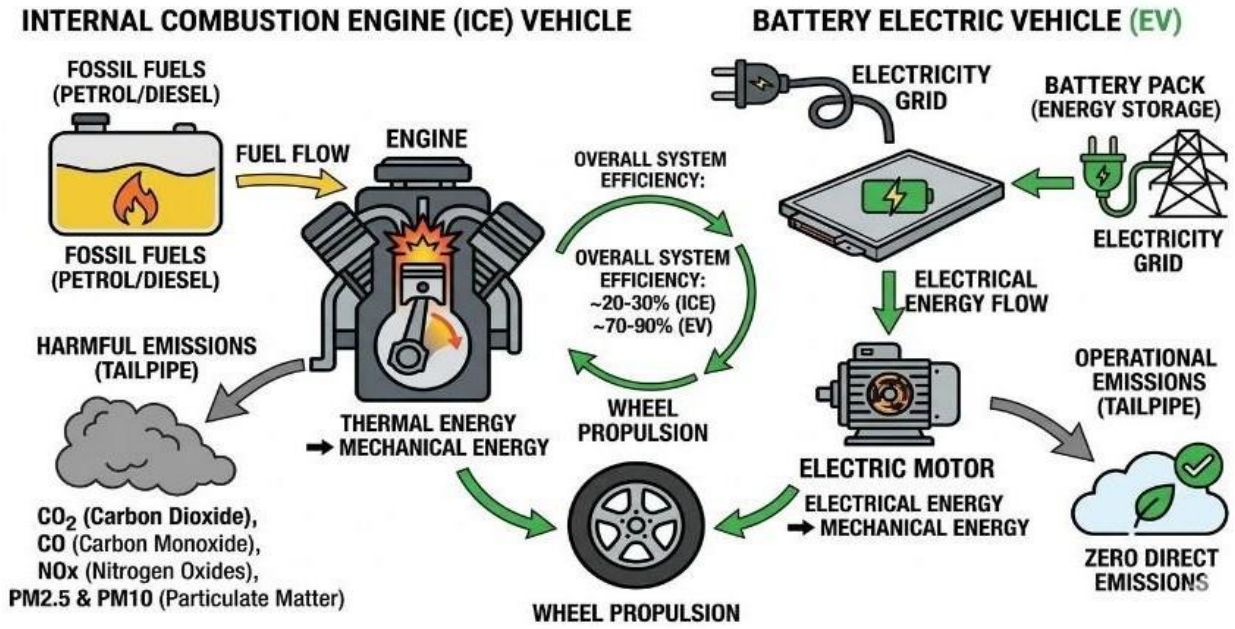


Figure 1: Comparison of Energy Flow and Emissions in ICE and Electric Vehicles

The increasing level of air pollution and greenhouse gas emissions in India has become a major environmental and public health concern. A significant portion of these emissions originates from the transportation sector, particularly due to the widespread use of Internal Combustion Engine (ICE) vehicles. Rapid urbanization, population growth, and increasing vehicle ownership have further intensified this problem, especially in urban areas. Although Electric Vehicles (EVs) are

being promoted as a sustainable alternative, their actual environmental benefits in the Indian context remain a subject of debate. This is primarily due to the continued reliance on fossil fuels for electricity generation and the environmental impacts associated with battery production and disposal. Moreover, there is a lack of region-specific studies that comprehensively evaluate the environmental implications of transitioning from ICE vehicles to EVs, particularly in cities. Limited public awareness, inadequate charging infrastructure, and high initial costs also act as barriers to the adoption of EVs.

Therefore, there is a need to systematically assess the environmental impact of this transition and to understand the associated challenges and opportunities. This study aims to address these gaps by analyzing both environmental and socio-economic aspects of EV adoption in the Indian context. This highlights the urgent need for sustainable transportation solutions such as Electric Vehicles, which can play a crucial role in reducing emissions and achieving climate goals. The transportation sector in India is undergoing a significant transformation due to rapid technological advancements and policy interventions. The shift towards electric mobility is not only driven by environmental concerns but also by the need to reduce dependence on imported fossil fuels. India faces the dual challenge of sustaining economic growth while minimizing environmental degradation. In this context, Electric Vehicles play a crucial role in achieving sustainable development.

II. REVIEW LITERATURE

2.1: Policy Reviews: FAME II and UP EV Policy 2022

Policy is the primary catalyst for the EV revolution. The FAME-II (Faster Adoption and Manufacturing of Electric Vehicles) scheme, successfully targeted the commercial segment but faced hurdles in private adoption due to high upfront costs and “Range Anxiety.” Literature suggests that the lack of a standardized charging protocol initially slowed the momentum of FAME-II.

Regionally, the Uttar Pradesh Electric Vehicle Manufacturing and Mobility Policy, 2022 [1] are a landmark document. Note that UP’s policy is unique because it combines “Demand Incentives” (100% tax waivers) with “Supply Incentives” (subsidies for setting up charging stations). Given that UP has the highest number of registered vehicles in India. The literature evaluates how state-level policies act as a “Buffer” against the high cost of Lithium-ion technology, making the transition feasible for middle-income consumers.

III. SCOPE OF THE STUDY

This study focuses on analyzing the environmental impact of the transition from Internal Combustion Engine (ICE) vehicles to Electric Vehicles (EVs) in India. The research primarily examines the role of the transportation sector in contributing to air pollution and greenhouse gas emissions in urban areas. The scope of the study includes a comparative assessment of ICE vehicles and Electric Vehicles in terms of emission levels, energy consumption, and overall environmental impact. It also considers key pollutants such as carbon dioxide (CO_2), nitrogen oxides (NOx), and

particulate matter (PM2.5), which are major contributors to deteriorating air quality. Furthermore, the study evaluates the influence of electricity generation sources in India, particularly the dependence on coal-based power, on the overall sustainability of Electric Vehicles. The life cycle perspective is also considered, including the environmental impact of battery production and disposal.

IV. GLOBAL AND NATIONAL STUDIES ON ICE VS EV

The transition from Internal Combustion Engine (ICE) vehicles to Electric Vehicles (EVs) is a cornerstone of the global "Green Recovery" strategy. Globally, the International Energy Agency IEA, 2023 [2] reports that the transport sector is the fastest-growing source of Greenhouse Gas (GHG) emissions. Research by Albatayneh, et al., 2020 [3] suggests that while ICE technology has reached a plateau in thermal efficiency (approx. 25-30%), EV drivetrains offer an efficiency of over 70%.

Nationally, the Indian perspective is distinct. NITI Aayog, 2021 [4] and CEEW (Council on Energy, Environment and Water, 2022) [5] have highlighted that India's high population density makes vehicular pollution a localized health crisis rather than just a global climate issue. Studies by Dhar et al., 2017 [6] emphasize that for a developing economy like India, the "National Mission on Transformative Mobility" must prioritize two-wheelers and public transport. This section of the literature establishes that while global studies focus on carbon neutrality, Indian national studies are increasingly focusing on "Energy Security" to reduce the massive crude oil import bill, which currently drains 4-5% of the national GDP.

The economic divergence between global and national research is a critical point of discussion in existing literature. While international studies by the World Bank 2022 [7] focus on the decarbonization of high-income economies, Indian researchers point out the 'Affordability Barrier.' Literature suggests that in a price-sensitive market like Uttar Pradesh, the high initial cost of EVs is a bigger deterrent than the lack of technology. Scholars argue that for India to replicate the success of Norway or China, the research must focus on low-cost 'Frugal Innovation' in battery assembly. This addition to the national discourse shifts the focus from purely environmental goals to a balanced 'Socio-Economic' transition.

V. ANALYSIS OF AIR POLLUTION AND EMISSION RESEARCH

The nexus between vehicular exhaust and deteriorating public health is well-documented in Indian academia. According to the CPCB, 2022 [8], the Indo-Gangetic Plain, which includes cities like Gorakhpur, suffers from unique topographical conditions that trap pollutants. Research by Guttikunda and Calori, 2013 [9] provided a breakthrough in "Source Apportionment," revealing that transport contributes significantly to the PM2.5 (Fine Particulate Matter) levels in Indian cities. Furthermore, WHO, 2023 [10] guidelines suggest that there is no "safe" level of exposure to PM2.5. Scholarly reviews by Pandey et al., 2020 [11] in The Lancet have quantified the economic loss due to air pollution-related premature deaths in India. The literature overwhelmingly supports

the adoption of EVs as a "Zero-Tailpipe" solution. However, recent critical studies by Timmers and Achten, 2016 [12] warn about "Non-Tailpipe Emissions" (NTE), such as brake and tire wear, which are often higher in heavier EVs.

A deeper analysis of air pollution research reveals that the impact of vehicular emissions is not uniform across all demographics. Medical journals like The Lancet, [13] (Child Health edition) highlight that children in urban centers are more vulnerable to PM2.5 because their breathing rate is higher than adults. In cities, where traffic congestion is frequent, children commuting in open vehicles (like cycle-rickshaws or autos) are exposed to peak concentration levels of Nitrogen Dioxide (NO_2). This literature emphasizes that the shift to Electric Vehicles is not just an atmospheric necessity but a 'Pediatric Emergency' to protect the respiratory health of the future generation. Furthermore, several studies emphasize that government policies such as subsidies, tax benefits, and state-level incentives play a crucial role in accelerating EV adoption in India. However, challenges such as uneven infrastructure distribution, high initial costs, and lack of consumer awareness still act as major barriers. Therefore, a combined effort of policy support and technological advancement is essential for sustainable growth of electric vehicles in the Indian context.

VI. BATTERY TECHNOLOGY AND LIFECYCLE ASSESSMENT (LCA) STUDIES

The "Green" credentials of an EV are frequently debated through the lens of Life Cycle Assessment (LCA). A seminal study by the Union of Concerned Scientists (2015) established that the "Cradle-to-Gate" emissions of an EV (manufacturing phase) are roughly 15% to 68% higher than those of an ICE vehicle. This is primarily due to the energy-intensive process of cell manufacturing and the mining of Lithium, Cobalt, and Nickel. Recent literature by Ahmadi et al., 2017 [14] explores "Second-life" applications for Lithium-ion batteries. Since a battery is considered "spent" for a vehicle once its capacity drops to 70-80%, researchers argue it can still serve for 10 more years in stationary energy storage (e.g., solar farms). In the Indian context, studies by IIT Madras, 2022 [15] highlight the "Thermal Management" crisis. Indian ambient temperatures frequently exceed 45°C, which causes faster chemical degradation of battery electrolytes compared to European standards. This creates a "Performance Gap" in Indian EVs that needs more localized longitudinal research. This highlights the need for region-specific battery performance studies under Indian climatic conditions.

Beyond the technical efficiency of Lithium-ion cells, recent literature has raised alarms regarding the 'Ethical Footprint' of EV batteries. Research by Amnesty International and environmental watchdogs has documented that the extraction of Cobalt and Lithium is linked to severe water depletion in the 'Lithium Triangle' of South America. Literature suggests that while an EV cleans the air in an Indian city, it may contribute to 'Hydrological Stress' in a mining region thousands of miles away. This 'Spatial Injustice' is a growing theme in environmental ethics research, suggesting that the long-term solution must involve 'Deep Recycling' or 'Cobalt-free' chemistries like LFP (Lithium Iron Phosphate) which are more suited for the Indian climate.

VII. RECENT TRENDS IN EV ADOPTION IN INDIA

Electric Vehicles (EVs) adoption in India has witnessed a significant increase in recent years due to supportive government policies, rising fuel prices, and increasing environmental awareness. The Government of India has launched several initiatives such as the Faster Adoption and Manufacturing of Electric Vehicles (FAME-II) scheme to promote EV usage across the country. The Indian EV market is primarily driven by the growth of electric two-wheelers and three-wheelers, especially in urban and semi-urban areas. E-rickshaws have become a common mode of transport in cities like Gorakhpur, contributing to reduced local air pollution. According to recent reports, India aims to achieve 30% electric vehicle penetration by 2030. Several automobile companies are investing in EV technology, battery production, and charging infrastructure development. The expansion of charging stations across highways and urban areas is further supporting EV adoption. However, challenges such as high battery cost, limited charging infrastructure, and dependency on imported lithium-ion batteries still exist. Despite these challenges, the future of EV adoption in India appears promising due to continuous technological advancements and policy support.

VIII. COMPARISON OF EV ADOPTION: DEVELOPED VS DEVELOPING COUNTRIES

Developed countries such as Norway, the United States, and China have achieved significant success in Electric Vehicle adoption due to strong policy frameworks, financial incentives, and advanced infrastructure.

Norway, for instance, has one of the highest EV adoption rates in the world due to heavy subsidies, tax exemptions, and widespread charging infrastructure. In contrast, developing countries like India face several challenges in EV adoption, including affordability issues, limited infrastructure, and lack of awareness. In India, the high upfront cost of EVs remains a major barrier for middle-income consumers. However, developing countries also have unique opportunities. For example, India's large two-wheeler market provides a significant opportunity for EV growth. Additionally, government initiatives and increasing private sector involvement are gradually improving the EV ecosystem in India. Therefore, while developed countries focus on technological advancement and carbon neutrality, developing countries like India must focus on affordability, infrastructure development, and public awareness to achieve successful EV adoption.

IX. ROLE OF RENEWABLE ENERGY IN EV SUSTAINABILITY

The environmental benefits of Electric Vehicles are closely linked to the source of electricity used for charging. If electricity is generated from fossil fuels such as coal, the indirect emissions associated with EVs may reduce their overall environmental advantage. In India, a significant portion of electricity is still generated from coal-based power plants. Therefore, the integration of renewable energy sources such as solar, wind, and hydro power is essential to maximize the environmental benefits of EVs. The use of solar-powered charging stations can significantly reduce

the carbon footprint of Electric Vehicles. Renewable energy integration not only supports clean transportation but also contributes to achieving national climate goals and reducing greenhouse gas emissions. Therefore, the future sustainability of Electric Vehicles depends on the transition towards a cleaner and greener energy mix. Promoting renewable energy along with EV adoption is crucial for achieving long-term environmental sustainability.

X. DISCUSSION

The findings of the study indicate that Electric Vehicles have strong potential to reduce environmental pollution in urban areas like Gorakhpur. Although awareness levels are relatively high, actual adoption is still influenced by economic and infrastructural challenges. The comparative analysis clearly shows that EVs are environmentally superior to conventional vehicles in terms of emissions and air quality improvement. However, the life cycle analysis highlights that the environmental benefits of EVs depend on factors such as electricity sources and battery management. Therefore, a combined effort from government, industries, and consumers is necessary to overcome existing challenges and promote sustainable transportation.

10.1 Socio-Economic Analysis of EV Adoption

The adoption of Electric Vehicles is not only influenced by environmental factors but also by socio-economic conditions. Income level, education, and occupation play a significant role in determining the acceptance of EV technology. Higher-income groups are more likely to adopt EVs due to their ability to afford the high initial cost. On the other hand, middle and lower-income groups are more dependent on conventional vehicles due to financial constraints. Education level also influences awareness and understanding of environmental issues. Individuals with higher education levels tend to be more aware of climate change and are more willing to adopt sustainable technologies. Occupation also plays a role in EV adoption. For instance, individuals involved in commercial activities, such as drivers of auto-rickshaws and delivery services, may prefer EVs due to lower operating costs. Therefore, socio-economic factors must be considered while designing policies for promoting Electric Vehicles in India.

10.2 Detailed Environmental Impact Discussion

The environmental impact of Electric Vehicles extends beyond emission reduction. EVs contribute to noise reduction, improved urban air quality, and reduced dependence on fossil fuels. Unlike ICE vehicles, EVs operate quietly, reducing noise pollution in urban areas. This can significantly improve the quality of life, especially in densely populated cities. Furthermore, EV adoption can reduce India’s dependency on imported petroleum, thereby improving energy security. However, the environmental impact of battery production and disposal must be carefully managed. Overall, Electric Vehicles represent a sustainable solution, but their long-term success depends on responsible resource management and technological advancements.

10.3 Policy Implications

Government policies play a crucial role in accelerating the adoption of Electric Vehicles. Strong

policy support in the form of subsidies, tax benefits, and infrastructure development is essential. Policies should focus on reducing the cost of EVs, promoting domestic battery manufacturing, and encouraging private sector participation in charging infrastructure.

10.4 Practical Implications

The findings of this study can be applied in real-world scenarios to promote sustainable transportation. Urban planners, policymakers, and environmental agencies can use this research to design effective strategies.

XI. CONCLUSION

The present study focused on analyzing the environmental impact of vehicular emissions and the potential role of Electric Vehicles (EVs) in reducing air pollution, particularly in urban areas like Gorakhpur. The study combined both primary data (survey-based analysis) and secondary data (literature review and emission comparisons) to understand the awareness, perception, and feasibility of EV adoption. Air pollution has emerged as a major environmental and public health concern, especially in rapidly urbanizing regions. The findings of this study indicate that conventional Internal Combustion Engine (ICE) vehicles are one of the significant contributors to air pollution due to the emission of harmful pollutants such as carbon dioxide (CO_2), nitrogen oxides (NOx), and particulate matter (PM2.5). These pollutants have severe impacts on human health, contributing to respiratory diseases, cardiovascular problems, and reduced quality of life. The analysis clearly shows that Electric Vehicles provide a cleaner alternative to conventional vehicles, as they produce zero tailpipe emissions. This makes them highly beneficial for improving urban air quality. However, the study also highlights that the environmental benefits of EVs depend on factors such as electricity generation sources and battery production processes. In the context of Gorakhpur, the study found that while awareness about EVs is relatively high, actual adoption is still limited due to economic and infrastructural challenges. The results indicate that people are willing to shift towards EVs, but concerns related to high initial costs, limited charging infrastructure, and lack of technical knowledge act as major barriers. Overall, the study concludes that Electric Vehicles have strong potential to reduce air pollution and contribute to sustainable urban development. However, a combined effort from government policies, technological advancements, and public awareness is necessary to ensure their large-scale adoption. The transition from Internal Combustion Engine (ICE) vehicles to Electric Vehicles (EVs) represents a crucial step towards achieving environmental sustainability in India. Rapid urbanization and industrialization have increased vehicular emissions, leading to severe air pollution problems. Electric vehicles offer a cleaner alternative as they produce zero tailpipe emissions, thereby reducing pollutants such as carbon monoxide, nitrogen oxides, and particulate matter. Moreover, the adoption of EVs can significantly reduce greenhouse gas emissions, especially when combined with renewable energy sources. This shift also helps in reducing dependency on fossil fuels and enhances energy security in the country. However, certain challenges such as high initial cost, limited charging infrastructure, and battery disposal issues need to be addressed. Therefore, it can

be concluded that although electric vehicles present some challenges, their environmental benefits outweigh the limitations. With proper government policies, technological advancements, and increased public awareness, the transition to electric vehicles can play a vital role in improving environmental conditions in India.

REFERENCES

[1]. Government of Uttar Pradesh, Uttar Pradesh Electric Vehicle Manufacturing and Mobility Policy 2022. Lucknow, India, 2022. [Online].
[2]. International Energy Agency, Global EV Outlook 2023. Paris, France: IEA, 2023. doi: 10.1787/cbe724e8-en.
[3]. Albatayneh, A., Assaf, M. N., Alterman, D., & Jaradat, M. (2020). Comparison of the overall energy efficiency for internal combustion engine vehicles and electric vehicles. Environmental and Climate Technologies, 24(1), 669-680.
[4]. NITI Aayog, India's Electric Mobility Transition Report. New Delhi, India, 2021.
[5]. Council on Energy, Environment and Water, State of EV Adoption in India. New Delhi, India, 2022.
[6]. S. Dhar, M. Pathak, and P. R. Shukla, "Electric vehicles and India's low carbon passenger transport: A long-term co-benefits assessment," Journal of Cleaner Production, vol. 146, pp. 139–148, 2017, doi: 10.1016/j.jclepro.2016.05.111.
[7]. World Bank, Global Transition to Electric Mobility. Washington, DC, USA, 2022.
[8]. Central Pollution Control Board, National Air Monitoring Programme Report. New Delhi, India, 2022.
[9]. S. K. Guttikunda and D. Mohan, "Re-fueling road transport for better air quality in India," Energy Policy, vol. 68, pp. 556–561, 2014, doi: 10.1016/j.enpol.2013.12.067.
[10]. World Health Organization, Air Pollution and Health Report. Geneva, Switzerland: WHO, 2023.
[11]. India State-Level Disease Burden Initiative Air Pollution Collaborators, "Health and economic impact of air pollution in the states of India: The Global Burden of Disease Study 2019," The Lancet Planetary Health, vol. 5, no. 1, pp. e25–e38, 2021, doi: 10.1016/S2542-5196(20)30298-9.
[12]. V. R. J. H. Timmers and P. A. J. Achten, "Non-exhaust PM emissions from electric vehicles," Atmospheric Environment, vol. 134, pp. 10–17, 2016, doi: 10.1016/j.atmosenv.2016.03.017.
[13]. The Lancet Child & Adolescent Health, "Air pollution impacts on children," 2020.
[14]. L. Ahmadi, S. B. Young, M. Fowler, R. A. Fraser, and M. A. Achachlouei, "A cascaded life cycle assessment of electric vehicles," Journal of Cleaner Production, vol. 158, pp. 392–402, 2017.
[15]. Indian Institute of Technology Madras, Battery Performance Study in Indian Conditions. Chennai, India, 2022.