Electric Mobility Adoption in India –Policy & Initiatives to Promote E-Mobility in Jharkhand

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[Abstract] Electric Vehicles (EVs) represent a practical and compelling alternative to traditional Internal Combustion Engine (ICE) vehicles, effectively addressing critical issues such as pollution and energy security in India. This study delves into India's EV ecosystem, examining policy initiatives, adoption trends, and challenges. A thorough analysis of government policies and relevant literature reveals a robust upward trajectory in EV adoption over the past 4-5 years. Investments in charging infrastructure have instilled confidence in Battery Operated Vehicles (BOVs) for both private and public use. Notably, Electric Three Wheelers (E3W) have experienced significant adoption, and passenger car fleets are gradually transitioning to electric models. Electric Two-Wheelers (E2W) also demonstrate rapid growth, with sales increasing by over 200% year-on-year. While green mobility options may entail some trade-offs in terms of cost and convenience, they offer substantial benefits such as fuel savings, reduced emissions, and improved health outcomes. It is crucial to promote green mobility while acknowledging existing challenges. Adopting a balanced approach will facilitate sustainable and efficient transportation, not only in Jharkhand but also in similar developing regions globally.

[Keywords] electric vehicles, EV policy, battery operated vehicles, charging infrastructure, sustainable transportation, emission reduction

Introduction

India ranks as the world's second-largest importer of crude oil, acquiring over 82% of its total oil needs from overseas sources. The transport sector alone consumes nearly all petrol (99.6%) and a majority of diesel (70%) in the country, contributing significantly to particulate matter pollution, which accounts for approximately one-third of India's total air pollution.

In terms of sales volume, India stands as the fifth-largest market for passenger vehicles globally (Deo et al., 2021). To address the challenges posed by the transportation sector's heavy reliance on imported crude oil and its significant contribution to air pollution and greenhouse gas emissions, both industry and government are actively exploring alternative powertrains and fuel technologies across all vehicle types. Meeting the goals of the Paris Agreement, which aims to limit global warming to 2 degrees Celsius, necessitates an ambitious 80% reduction in vehicular greenhouse gas emissions by 2050.

Green mobility, as defined by Ausubel et al. (1998), involves transportation systems designed to minimize environmental disruption. Currently, among various alternative fuel technologies and powertrains under development, only battery-operated electric vehicles (BEVs) and hydrogen fuel cell-based vehicles demonstrate the potential to significantly reduce greenhouse gas emissions in line with the Paris Agreement's objectives (Bieker, 2021).

While Hydrogen fuel cell-based vehicles are still in the developmental stage, Battery-operated Electric Vehicles (BEVs) stand as the only commercially available green vehicles in the Indian market. The transition from conventional Internal Combustion Engine (ICE) vehicles to BEVs represents a promising strategy for decarbonizing transportation. India has committed to achieving a target of at least 30% annual sales share of Electric Vehicles by 2030 and is part of a select group of countries supporting the global EV30@30 campaign (as outlined in the Handbook of Electric Vehicle Charging Infrastructure Implementation, Version-1 published by NITI Aayog in 2019).

Although Battery-operated Electric Vehicles have been commercially available in various segments in India for around 10 years, their adoption in the market remains negligible, with a market share of below half a percent of total passenger vehicle sales (Deo et al., 2021). The Government of India, through its Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, and various State Governments, through their Electric Vehicle policies (EV Policies), incentivize, prioritize, and provide opportunities for the development of an ecosystem for manufacturing, adoption, infrastructure, and services for an electric mobility future (NITI Aayog, 2019).

Despite significant efforts and emphasis by the industry and government, the extremely slow adoption of Electric Vehicles in the market and among consumers warrants a detailed analysis of techno-commercial, infrastructure, and marketing factors that affect the adoption of Battery-operated Electric Vehicles. However, a steep rise of more than 200% year-on-year in the sales of Passenger Electric Vehicles in the last few quarters strongly advocates for a promising future and rapid adoption of Electric vehicles.

Statistical Presentation Of EV Adoption In India

Before we delve further into various aspects of EV adoption and its ecosystem, let us first analyze the EV sales data for the last ten FYs to understand its acceptance among users. Table 1 provides a comparative data of adoption of EVs amongst the total vehicles sold in the country for the last ten financial years (VAHAN Dashboard, Government of India):

Table 1

Sales of Vehicles Last 10 Years and BOV Penetration

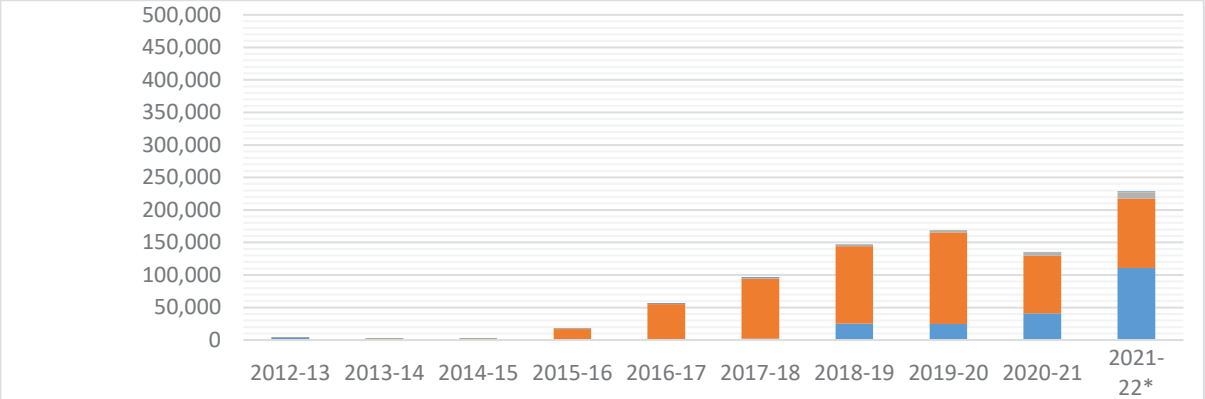
Financial Year(FY)	Electric(BOV) Sale	Total Vehicles Sale	% Penetration
2012-13	4,075	1,58,70,999	0.0
2013-14	3,003	1,63,20,454	0.0
2014-15	2,380	1,75,17,170	0.0
2015-16	17,978	1,82,54,049	0.1
2016-17	56,558	1,94,70,714	0.3
2017-18	96,756	2,14,14,279	0.5
2018-19	1,46,591	2,25,72,858	0.6
2019-20	1,68,320	2,18,60,639	0.8
2020-21	1,34,849	1,53,61,056	0.9
2021-22	2,28,571	1,14,65,159	2.0

Source: VAHAN Portal, Government of India (GoI))

The sales volume of EVs is negligible compared to ICE vehicles and merely accounts for even less than 2% of total vehicular sales in the country. Figure below illustrates the sales data across segments and the growth pattern of EVs in the country.

Figure 1

Sales of EVs Across the Segment

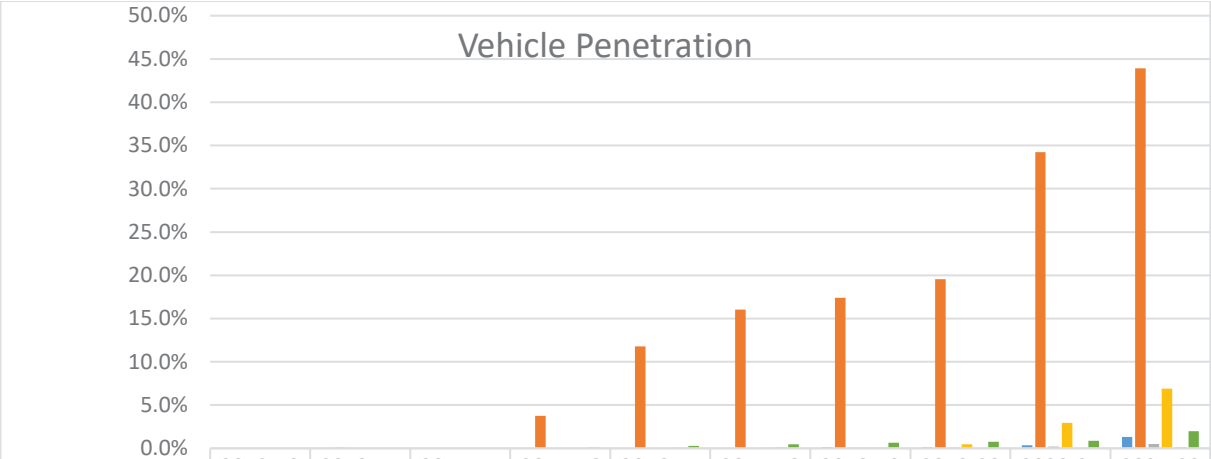


	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22*
Other	319	282	196	194	602	1,230	768	72	65	1,019
Buses	1	3	3	4	7	38	78	446	374	766
Cars	336	481	593	788	768	1,221	1,496	2,276	5,008	9,061
Three-wheeler	74	398	44	15,518	53,794	92,374	118,889	140,684	88,391	106,743
Two-wheeler	3,345	1,839	1,544	1,474	1,387	1,893	25,360	24,842	41,011	110,982

Source: VAHAN Portal, GoI

Figure 2

Segment-Wise Penetration of Evs in the Market



	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Two-wheeler	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.4%	1.3%
Three-wheeler	0.0%	0.1%	0.0%	3.8%	11.8%	16.1%	17.4%	19.6%	34.2%	43.9%
Four-wheelers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.5%
Buses	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.5%	2.9%	6.9%
Other	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%
Total	0.0%	0.0%	0.0%	0.1%	0.3%	0.5%	0.6%	0.8%	0.9%	2.0%

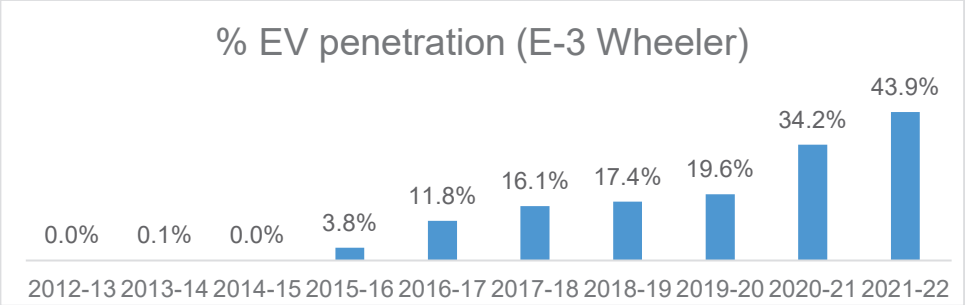
Source: VAHAN Portal

Even though the present-day data is not very encouraging, the sales figure of Electric 3- wheelers across the country shows a ray of hope for the E-mobility sector. E3Ws have continued to maintain rapid growth in

sales figures year-on-year with a market penetration of around 44% so far in the ongoing FY 2021-22. Let us have a closer look at E3W sales figures in the figure below:

Figure 3

Graphical Representation of EV Penetration in 3 Wheeler Segment



Source: VAHAN Portal, GoI

Now let us analyze and compare the EV penetration data for Jharkhand. Table 2 below provides sales data and penetration of EVs for last 6 FY.

Table 2

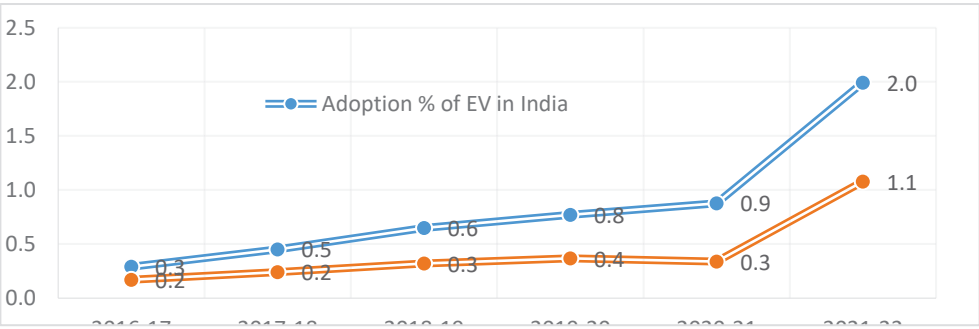
Sales And Penetration Data for Evs In Jharkhand

	ELECTRIC(BOV) Sale	Total Vehicles Sale	% Penetration
2016-17	799	468888	0.2
2017-18	1471	607984	0.2
2018-19	1985	619347	0.3
2019-20	2169	590839	0.4
2020-21	1538	455377	0.3
2021-22	4160	385589	1.1

Source: VAHAN Portal

Figure 4

Comparison of EV Penetration % in India and Jharkhand



Source: VAHAN Portal

The above data clearly shows that the state of Jharkhand is lagging well behind the national rate of adoption of EVs.

History of E-Mobility in India

Globally, the turning point occurred in September 1990 when the California Air Resources Board (CARB) adopted the Zero-Emission Vehicles (ZEV) regulations. Initially, these regulations required that 2% of all passenger cars and light trucks sold in the state by significant car manufacturers emit zero exhaust, starting with the 1998 models. Subsequently, the percentage of ZEVs increased to 5% in 2001 and 10% in 2003. However, the industry seemingly resisted this technology and regulatory forcing, resulting in limited growth in electric mobility.

India currently ranks among the top 10 countries with vehicle and component manufacturing capabilities. Remarkably, this growth was achieved in just 30 years, compared to over a hundred years in Germany and the US, and around 70 years in Japan. Despite this rapid growth, India's technology capabilities are still maturing. While vehicle companies possess design and product development capabilities, component manufacturers often import technologies through joint ventures. Competitiveness is achieved through "frugal engineering," which involves thrifty shop floor innovations and resource conservation.

Automotive companies in India are striving to catch up with the growth curve to narrow the gap with developed countries. The vast domestic market works in their favor, and many IC engine vehicle technologies can be obtained from Tier-1 company sources. However, future growth at this level is not guaranteed, as competition is emerging from electronics and electrical technologies, which pose a challenge for the Indian automotive sector.

Globally, mainstream manufacturers are offering several models of Hybrid Electric Vehicles (HEVs), and many well-established vehicle brands are planning a complete conversion to hybrids. This shift has significantly altered the technology base. The widespread adoption of Lithium-ion batteries by global Original Equipment Manufacturers (OEMs) since 2010 has created a significant technology and manufacturing capability gap, as these batteries appear to be beyond the reach of Indian companies.

It is concerning because by 2020, xEVs (Electric Vehicles and Hybrid Electric Vehicles collectively) are expected to become a mainstream choice for customers globally. The Ministry of New & Renewable Energy (MNRE) ran a scheme from 2010 to 2012, allocating INR 95 crores to provide up to 20% incentives on the ex-factory price of EVs, with a maximum incentive of INR 1 lakh for an electric car. Additionally, the import duty on batteries was reduced from 26% to 4%.

This initiative led to a surge in demand for 2W-EVs to a hundred thousand units in 2011-12. However, when the subsidy was withdrawn, sales dropped to 42,000 in 2012-13 and 21,000 in 2013-14. Consequently, nearly a thousand dealer outlets and 26 out of 35 small Electric Two-Wheeler (E2W) assembler manufacturers were forced to close. Since the withdrawal of subsidy support, the sole electric car manufacturer in the country has only been able to sell 3000 cars.

In recent years, the situation has undergone a dramatic change due to global climate change concerns, notably highlighted by reports from the Intergovernmental Panel on Climate Change (IPCC) and UN Conventions/Treaties. There is a growing desire to reduce liquid fuel demand through large-scale electrification of the light-duty vehicle fleet. Most developed countries have devised roadmaps for the electrification of transport systems and have well-funded programs that offer consumer incentives to offset the increased cost of electrified vehicles, create domestic pilot markets, support new technology developments, manufacture key components like batteries, and incubate specialist/start-up companies.

Policy Initiatives to Enable and Promote EV in India

2010	• Electric vehicle (EV) advocacy program from the MNRE • In 2010, India made a pivotal move toward promoting EVs: Significant adoption, especially of e-bikes, occurred after the Ministry of New and Renewable Energy (MNRE) suggested a 20% capital subsidy for EVs.
2011	• The Government of India has launched the National Mission for Electric Mobility (NMEM). • To promote electric mobility by developing and deploying EVs.

	• Approval for the establishment of the National Council for Electric Mobility (NCEM) and the National Board for Electric Mobility (NBEM) (NBEM) • To establish the National Automotive Board (NAB) to provide technical advice.
2013	• The Ministry of Heavy Industry's National Electric Mobility Mission Plan 2020 (NEMMP 2020) • NEMMP will be launched in order to attain the following goals by 2020: • 7 million EV sales USD 2 billion in fuel savings • CO2 emissions will be reduced by 1.3 to 1.5 percent. • Create an additional 60,000-65,000 jobs.
2015	• FAME stands for Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles by the Ministry of Heavy Industry. • FAME - I India pilot phase begins: • A budget of 7.95 billion INR (122 million USD) is planned for the next two years. • Technology/benefit-based incentive allocation • 2W, 3W, 4W, LCV, HCV, and Retrofit vehicles are all eligible. • Major metros, capitals, Smart Cities, and cities in the northeastern states are excluded. • The government intends to establish FAME-2 with demand-side incentives and aggregation subsidies in mind.
2018	• The Government of India sets target of 30% Sales of EV out of total vehicle sales in 2030.
2019	• FAME – II • The Centre has authorized a Rs. 10,000 crore budget for FAME-II. • The scheme will be in effect for three years beginning in April 2019. • The scheme's incentives are geared for commercial vehicles powered by lithium-ion batteries, such as electric buses, passenger cars for taxi aggregators, three-wheelers, and two-wheelers. • The Department of Heavy Industry (DHI) has approved public procurement for 2,636 EV Charging Stations in 62 cities throughout 24 states/UTs, as well as 1,544 such stations on highways.
2021	• FAME II demand incentive increased to INR 15000/- per kWh (USD 200 per kWh) of battery capacity and capped at 40% of vehicle cost. • Aggregate demand for 3 lakh 3 wheelers across several user segments to reduce the upfront cost of E3W to the same level as ICE 3 wheelers. • On an OPEX basis, aggregate demand for e-buses in 9 cities (with a population of more than 4 million) under the scheme.

EV Policies of Different States in India

Policies	Salient Features
Karnataka EV and Energy Storage Policy September 2017	• Rewards for the first 100 charging stations • 1000 electric buses will be introduced. • To alter building bylaws in order to provide charging outlets and consistent electricity supply • The formation of an SPV to build more changing infrastructure in Bengaluru and Karnataka. • Electric vehicles will be tax-free.

	• Incentives for the manufacturing of EVs, batteries, and components
Uttar Pradesh EV Policy March 2018	• The state plans to introduce 1000 electric buses by 2030. • By 2020, green paths will be found. • Tax exemption for purchasers, interest-free loans, and a 30% subsidy on the on-road price of EV Electric Vehicle Incubation centers will be established at IIT-Kanpur
Andhra Pradesh EV Policy May 2018	• In five years, investment of INR 30,000 crore in manufacturing and charging infrastructure. • The state aims to produce 10 GWh of EV batteries. • By 2030, the state's APSRTC bus fleet should be all electric. • The state aims to have 10 lakh EVs by 2024.
Kerala EV Policy October 2018	• For three years, new electric vehicles are exempt from paying road taxes. • Karnataka State Electricity Board EV will establish charging infrastructure, and accessory manufacture will be encouraged under the ESDM and IT Policy. • E-mobility zones, subsidized electricity tariffs, and 3 W incentives
Delhi EV Policy November 2018	• All electric vehicles qualified for FAME India will have their road tax, registration costs, and MCD one-time parking fee waived. • Scrapping and de-registration incentives of up to $15,000 for ICE 2W Pure electric buses that account for at least 50% of all new state-carriage buses purchased, with a target of 1000 pure electric buses in 2019. • Building code changes to include 'EV ready' ECS sites with conduits placed • A critical goal of this initiative is to provide accessible public charging facilities within 3 kilometers of everywhere in Delhi. • An eco-system for battery recycling will be built.

Review of Literature

The exploration of emerging industries and their development within the electric mobility sector has attracted significant scholarly attention in recent years. Mäkelä et al. (2011) initiated this discussion by conducting action research to uncover the underlying logic of value creation embedded within business models. They employed a participatory four-cycle model inspired by Coughlan & Coghlan (2002), involving planning, action, evaluation, and subsequent planning, which facilitated collaborative data gathering and improved both practical action and scientific understanding. However, data limitations due to strategic secrecy hindered the analysis, despite the usefulness of the business model canvas as an action research tool.

Subsequent studies, such as those by Dijk et al. (2012) and Laurischkat et al. (2016) further explored the electric mobility domain, identifying factors driving its advancement and elucidating key business model patterns and client segmentation. These frameworks not only shed light on existing business models but also paved the way for systematic business model development, aligning with contemporary tools like Value Proposition Design and Company Model Navigator.

Further research efforts, such as those by Krommes et al. (2017) and Shalender et al. (2018), expanded the discussion by examining crucial business model criteria, evaluating industry readiness for

transformation, and identifying obstacles to electric vehicle (EV) adoption. Krommes et al. (2017) highlighted varying levels of readiness among German vehicle manufacturers and underscored the evolving role of automobile makers in providing comprehensive electric mobility solutions. In contrast, Shalender et al. (2018) proposed an integrative framework to address barriers and opportunities for widespread EV adoption in India.

Complementing these studies, Gupta et al. (2018) and Ramji et al. (2019) provided comprehensive reviews of global electric vehicle policies and industry readiness, stressing the importance of strategic planning and transition amid the shift from internal combustion engine vehicles to electric mobility solutions. Together, these studies emphasize the interdisciplinary nature of research in this field, integrating insights from business models, policy analysis, and technological advancements to inform sustainable urban mobility strategies.

The evolving landscape of electric vehicle (EV) research is multifaceted, encompassing various dimensions ranging from business implications to adoption factors and policy considerations. In their Nordic-centric study, Rubens et al. (2019) conducted extensive interviews to unravel the intricacies of the business implications of electric cars. They revealed challenges stemming from legacy industries, inefficient supply chains, and disrupted sales and maintenance models. Charging infrastructure and range emerged as crucial determinants influencing mass adoption, emphasizing the need for tailored service-level models.

Building upon this, Castillo et al. (2019) undertook a comprehensive investigation into the factors shaping EV adoption. Considering government policies, vehicle characteristics, infrastructure, price, social and personal factors, and environmental concerns, their four-dimensional conceptual approach highlighted emotional value and value for money as primary motivators for potential EV adopters. This holistic understanding contributes nuanced insights for policymakers and businesses navigating the complex landscape of EV adoption.

Furthering the discourse, Sarode et al. (2020) provided a comprehensive overview of electric mobility in India, emphasizing government initiatives and challenges. While outlining an integrative framework, the study did not delve into consumer responses to policies, leaving room for future research to explore the interplay between policy interventions and public reception.

Addressing psychological factors, Huang et al. (2021) investigated the influence of the need for uniqueness (NFU) on sustainable innovation adoption in the context of electric vehicles. Their findings identified NFU as a positive predictor of psychosocial value perception, adding a psychological dimension to the understanding of EV adoption. Verma et al. (2020) explored EV awareness and consumer preferences in Bengaluru, India, highlighting the role of fuel economy and government subsidies. The study, while insightful, raised questions about its representativeness due to a limited sample size. Abd Alla et al. (2021) focused on decarbonizing and electrifying the transportation sector, emphasizing positive impacts and energy savings associated with electric mobility.

Anastasiadou et al. (2021) acknowledged the importance of alternative electric vehicles (AEVs) for sustainable urban mobility, providing valuable guidance for policymakers on infrastructure development.
Das et al. (2022) analyzed government policies' relevance and impact on electric vehicle adoption in India, emphasizing the role of state governments and addressing concerns about Li-ion battery disposal. Digalwar et al. (2022) examined barriers to sustainable EV production in India, with a focus on technology as the most critical factor. Verma et al. (2023) recognized the potential benefits of EVs in reducing CO2 emissions but raised concerns about infrastructure challenges, emphasizing the importance of promoting shared mobility and public transportation. Together, these studies offer a comprehensive understanding of the intricacies surrounding EV research, contributing valuable insights for industry stakeholders, policymakers, and researchers navigating the dynamic landscape of electric mobility.

Overview of Key Themes and Findings

Electric Vehicle (EV) Fire Safety

- Several papers focus on the safety aspects of electric vehicles, especially in enclosed spaces like tunnels and parking garages.

- They highlight the importance of understanding the root causes of EV fires to develop effective safety measures.
- Encouragingly, statistics do not indicate that EV fires are more common than internal combustion engine vehicle fires.

Consumer Perception and Awareness

- Research in India reveals that awareness about electric vehicles among the public is limited.
- Cost and comfort are significant factors influencing consumer preferences.
- Government support, subsidies, and infrastructure development are essential to boost EV adoption.

Barriers to EV Implementation

- Multiple papers discuss barriers to electric vehicle adoption, particularly in developing countries.
- Barriers include battery technology, vehicle performance, charging infrastructure, consumer behavior, and government support.
- Charging infrastructure and overall costs emerge as key determinants of EV demand.

Environmental Impacts

- Several papers analyze the environmental impacts of widespread EV adoption.
- The environmental benefits of EVs depend on factors such as the source of electricity used for charging.
- Transitioning to EVs can strain energy grids and increase emissions in the short term, but long-term benefits are expected with a shift to renewable energy sources.

Integration with Renewable Energy

- Papers emphasize the importance of integrating EVs into smart grids and utilizing renewable energy sources for charging.
- Smart grid integration can help manage the increased energy demand from EVs efficiently.
- Some papers suggest that EV adoption could stimulate investment in renewable energy projects.

Government Policies and Support

- The role of government policies, subsidies, and incentives in promoting EV adoption is a recurring theme.
- Governments play a crucial role in shaping consumer behavior and supporting the development of EV infrastructure.

Infrastructure Development

- Infrastructure-related challenges, including charging networks and grid capacity, are discussed in several papers.
- Effective infrastructure development is seen as pivotal for the growth of the EV market.

Battery Technology

- Battery technology is a central focus, with papers highlighting its importance for EV performance and sustainability.
- Advances in battery technology are seen as key drivers of EV adoption.

Sustainability and Climate Goals

- The adoption of EVs is often framed as a response to environmental challenges and a way to meet sustainability and climate goals.

Initiatives by Government of Jharkhand for promotion of E-Mobility in the State

The government of Jharkhand has implemented various policies and initiatives to promote green mobility and traditional transportation in the state. Here are some of the key measures:

Electric Vehicle Policy: In 2021, the Jharkhand government launched an Electric Vehicle Policy aimed at encouraging the adoption of electric vehicles. The policy offers incentives and subsidies to individuals and businesses for purchasing electric vehicles and setting up EV charging stations. Its goal is to reduce air pollution, promote sustainable transportation, and create new job opportunities in the EV industry.

Promotion of Public Transport: The government is committed to promoting public transportation as a sustainable mode of transport. It has invested in the development of bus and train infrastructure and is working to improve the quality and efficiency of public transport services.

Encouraging Cycling: Several initiatives have been launched to promote cycling as an eco-friendly and healthy mode of transportation. The government has developed dedicated cycle tracks and encourages the use of bicycles for short-distance commuting.

Promotion of Biofuels: The state government is promoting the use of biofuels as an alternative to fossil fuels. It has set up biofuel plants and is encouraging farmers to cultivate biofuel crops.

Green Mobility Awareness Campaigns: The government is conducting awareness campaigns to educate the public about the benefits of green mobility. It promotes the use of public transport, carpooling, and cycling while discouraging the use of private vehicles.

Fuel Efficiency Standards: Fuel efficiency standards have been implemented for vehicles to encourage the use of more efficient and less polluting vehicles in the state.

Smart City Initiatives: The government is promoting smart city initiatives that incorporate green mobility solutions such as electric vehicles, smart public transportation systems, and sustainable urban planning.

Promotion Due to Technology Advancement

The effects of technology improvements in implementing green mobility over traditional mobility in Jharkhand can be significant. Here are some possible effects:

Reduced Carbon Emissions: Green mobility technologies, such as electric vehicles, biofuels, and public transport systems powered by renewable energy sources, can significantly reduce carbon emissions compared to traditional modes of transportation. This can help Jharkhand achieve its climate goals and improve air quality.

Improved Efficiency: Advanced technologies, such as regenerative braking systems, lightweight materials, and intelligent traffic management systems, can improve the efficiency of green mobility solutions and reduce operating costs for businesses and individuals.

Reduced Dependence on Fossil Fuels: By promoting the use of renewable energy sources and alternative fuels such as biofuels, Jharkhand can reduce its dependence on fossil fuels and improve energy security.

Job Creation: The development of a green mobility ecosystem can create new job opportunities in areas such as EV manufacturing, battery production, charging infrastructure, and public transport services.

Health Benefits: Reducing air pollution and promoting physical activity through cycling and walking can have significant health benefits, including reducing the incidence of respiratory and cardiovascular diseases.

Conclusion and Discussion

In the pursuit of sustainable transportation alternatives, Green Vehicles present a compelling proposition, offering manifold advantages for all stakeholders and the environment alike. However, despite their potential, their presence within the Indian market remains tentative, rooted in a complex web of factors. This inquiry aims to chart this uncharted territory, shedding light on the myriad gaps in technological readiness, consumer convenience, divergent expectations, and the pivotal economic viability quotient. The illumination provided serves as a beacon not only for academia but for all actors in this dynamic landscape.

Collectively, the research papers considered offer a panoramic vista of the electric vehicle terrain, providing critical insights into overcoming barriers to adoption, advocating for the symbiosis of electric vehicles with renewable energy resources, and emphasizing the importance of safety and sustainability. These scholarly undertakings underscore the catalytic role played by governmental policies and incentives, particularly in developing nations. It becomes apparent that the transition toward electric mobility is not merely novel but a strategic response to mitigate greenhouse gas emissions, compromised air quality, and fossil fuel dependence. This trajectory points toward a future reconciled with environmental equilibrium, achievable through meticulous planning, judicious investment, and concerted efforts in developing robust infrastructure. Future research could involve conducting a primary survey to explore challenges experienced by sellers and consumers, providing an in-depth examination of the evolving dynamics within the electric vehicle market.

In conclusion, the body of literature presents a compelling argument for green mobility as a solution to the ecological challenges posed by traditional transportation paradigms in Jharkhand. By reducing greenhouse gas emissions and improving air quality, green mobility offers the prospect of a sustainable future. These findings suggest that transitioning to sustainable modes of transportation, such as electric vehicles and enhanced public transit systems, has the potential to transform the current environmental and public health landscape in Jharkhand. In contrast to the negative impacts of conventional mobility, this message underscores the promise inherent in the vision of green mobility.

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