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Revitalizing 4W Electric Vehicle Adoption in Tier II city of India: A Case study of Lucknow through Technology-Policy- Sustainable Framework (TPSF)

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Abstract
Lucknow is the capital and the largest city of the most populous Indian state i.e., Uttar Pradesh. It is among the topmost polluting cities in northern India. As per the CSIR-Indian Institute of Toxicology Research (IITR), vehicular emissions are the major contributors to deteriorating air quality. The transition towards Electric Vehicles (EVs) is not only pivotal in mitigating environmental degradation but also in reducing dependency on fossil fuels. One of the focus areas for the UP EV Manufacturing and Mobility Policy 2022 is to promote transition and faster adoption of EVs. However, the transition and adoption in Tier II cities (such as Lucknow) depends on ACTA (Affordability Convenience, Technology, and Awareness). There is a lack of synergy between the policy objective and the implementation framework. This study aims to analyze and bridge the gap between the two by evaluating the Comprehensive Electric Mobility Plan for Lucknow (CEMP: Lucknow) through Technology-Polity-Sustainable Framework (TPSF). The TPSF is based on circular economic principles. The adoption of EVs presents an opportunity to overhaul the transportation sector in the city. Implementing the policy directives for faster adoption of EVs is critical for achieving the goal of the EV30@30 campaign, thereby contributing significantly towards Net Zero 2070 targets. Insights from this research paper would inform policymakers, and automobile manufacturers on strategies to drive the transition towards a sustainable EV ecosystem.

KEYWORDS:
Electric Vehicles, Lucknow, Sustainable Development Goals, Policy Analysis, Uttar Pradesh, Resource Efficiency, Technology-Polity-Sustainable Framework (TPSF).

Introduction

India is on the verge of e- mobility revolution. To transcend the challenges and expedite this shift, the Government of India has implemented numerous measures. The country endorses the worldwide EV30@30 initiative, which strives for a minimum of 30% of new vehicle sales to be electric by 2030. As indicated by NITI Aayog, India aims to achieve a 30% market share of electric vehicles (EVs) for 4W passenger cars, 70% for commercial vehicles, 40% for buses, and 80% for two- and three-wheelers by 2030 [4].

It is projected that the electric vehicle market will be US $7.09 billion by 2025, which is currently at US$ 2 billion. To achieve a 30% market share for 4W passenger cars, India has set a target to increase its existing renewable energy capacity threefold. According to a report by Bain & Co., it is projected that by 2030, electric passenger vehicles will account for roughly 15 to 20 percent [2].

According to the Economic Survey of India 2023, the domestic electric vehicle market in India is expected to develop at a strong compound annual growth rate (CAGR) of 49 percent between 2022 and 2030. The survey predicts that by 2030, there will be approximately 10 million electric car sales in India on an annual basis. Projections suggest that the electric vehicle (EV) industry will create almost 50 million employment possibilities,

both directly and indirectly, in the coming seven years [2]. Metropolitan cities such as Lucknow are leading the way in the transition to electric mobility. Due to their high automobile demand, these areas are becoming centers for early electric vehicle (EV) adoption.

1. Literature Review

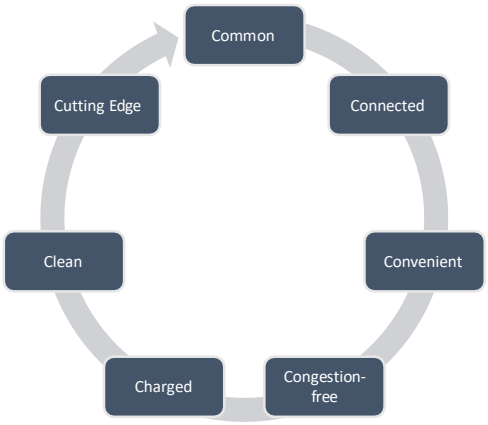

Figure 1(a): 7Cs for Future Mobility

In the words of Prime Minister Narendra Modi, future mobility in India would be like as depicted in the figure. The current landscape of electric mobility only caters to some Cs in India. Electric Vehicles (EVs) are being promoted as clean, charged, cutting-edge, and sustainable modes of commutation. It still lags in addressing the other Cs (common, connected, convenient, congestion-free) of future mobility.

The Indian state of Uttar Pradesh (UP) is being chosen as a case study because it is the market leader in terms of electric adoption. It contributes 26% of the total adoption in India. In Uttar Pradesh for the year 2023, the market share of electric vehicles (EVs) comprised of E-Rickshaws accounted for a significant majority at 81.62%, followed by E-2 wheelers at 16.05%, E-4 wheelers at 1.93%, and Cargo 3-wheelers at 0.36% [4]. The major contribution is from the 3W segment which is being majorly deployed for commercial purposes.

UP has the potential to become the leader in the mass adoption of electric vehicles if laws, legislation, and guidelines are effectively implemented [5]. This study critically analyzes the Comprehensive Electric Mobility Plan for Lucknow (CEMP—Lucknow) through TPSF. The objective of this study is to contribute towards faster adoption of electric vehicles in UP.

2. Methodology

The 11R determinants of the Technology-Polity-Sustainable Framework (TPSF) are deployed. The 11R determinants are inspired from the 9R framework [3]. The TPSF consists of 3 systems. 1) Technology 2) Polity 3) Sustainable. The system represents all the stakeholders. a) Legislative Bodies b) Multi-National Corporations c) Government Bodies/Agencies d) Consumers e) Non-Governmental Organizations f) Others

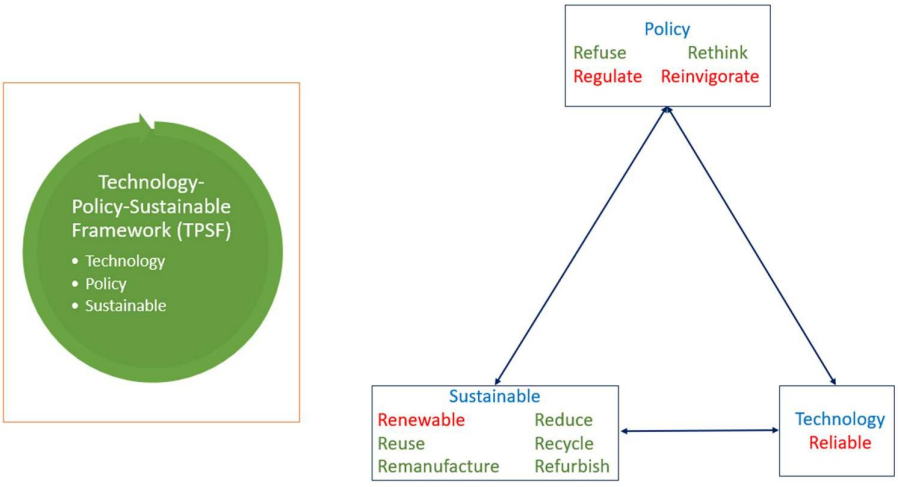

Figure 1(b): Research

Technology-Policy-Sustainable Framework (TPSF)

Framework

Technology-Polity-Sustainable Framework (TPSF): 11R's		
Systems	**Determinants**	**Definition**
Technology	**Reliable***	Technologies play a pivotal role in societies. It has the potential to democratize information and assist in formulating informed policies. It ensures transparency and accountability in the system. It fosters innovation. Research and investment in reliable, scalable future technologies are needed of the hour. Sustainable resources for research and development in cutting-edge technologies are paramount for any country's growth. It has the potential to break or make the world, impacting the entire humanity. Technology plays an important role in achieving sustainability. It has the potential to bridge the rural-urban, rich-poor, and gender divide in developing and developed societies. Reliability depends upon affordability and accessibility to technology. In this framework, the viability of the technology is the key component, which determines the wider adoption/dissemination of the products/services. Promotion and collaboration for research and development in cutting-edge technologies are paramount in the 21st century. It has the potential to break or make the world, impacting the entire humanity. Scalability and cost-effectiveness define the readiness towards any technology. If the technology is more accessible and readily available there are chances that it will be widely adopted. Defining public policy objectives through a technological framework ensures that the benefits reach the masses irrespective of the large number of beneficiaries. It strengthens minimum government and maximum governance principles for any country.
Polity	**Refuse**	It means not only abstaining from unsustainable consumption practices but also declining them. It is the most important determinant since all the other product development processes start after passing this stage. It encourages consumers and businesses to carefully assess their needs and make deliberate decisions and choices.
	Rethink	It refers to redesigning and redeveloping the product to reduce the carbon footprint. It challenges the linear creative boundaries and brings it closer to circular natural systems that value sustainability and the efficient use of resources. Framing policies, and passing laws, if not present. This can be done at three/four levels i.e., global, national, sub-national, and district levels.
	Regulate*	Governments have the prime responsibility to regulate and ensure welfare maximization of the people, by the people, and for the people. Policy directives or guidelines strengthen the ecosystem for wider adoption of sustainable consumption and production. Regulating the processes, and stakeholders and providing minimum government and maximum governance for developing a transparent and accountable ecosystem, for wider adoption/dissemination of the product/services. Strengthening the policy/act by allocating funds, appointing functionaries, and implementing the functions. It is the extremely critical pillar in the policy module that framing laws without teeth is just like drawing a paper tiger. Regulation is critical for ensuring transparency and accountability among the different stakeholders. Thereby upholding the cardinal principles of welfare maximization: by the people, of the people, and for the people
	Reinvigorate*	Strengthening the re-framed policy/act by allocating funds, appointing functionaries, and objectively defining the functions. To strengthen any policy, resources are essential and critical. The adoption of electric vehicles depends on easy access to **Natural Resources:** The minerals mined to produce the batteries need to be

		sustainable. Need-based production should replace greed-based production. **Human Resources:** A skilled, and efficient EV workforce is critical for the country like India. **Financial Resources:** Finance is critical for sustaining any policy, scheme, social, or infrastructural program. Governments across the world try to raise investments and funds through multiple channels. The fight against climate change needs a more inclusive approach to accessing climate finance for achieving sustainable development goals.
Sustainable	**Renewables***	Energy used for producing sustainable/green products should come from renewable sources. In developing and developed countries, where energy is still procured from non-renewable sources, it becomes imperative for reinvigorating international collaboration and cooperation for access to clean energy. Public policymaking overlooks the potential benefits of renewables. Renewables are not only limited to energy production or storage. Renewables are a lifestyle choice that needs to be incorporated and reflected in public policy.
	Reduce	Reducing excessive production and moving towards sustainable practices of production and consumption. Responsible production and consumption should be the cardinal guiding principle while formulating policies for exploitation of the natural resources. It seeks to optimize the exploration of natural resources, thereby minimizing the waste creation. Reducing the wasteful generation and moving away from unsustainable practices of production and consumption.
	Recycle	Recycling practices should be incorporated into the policy to reduce wastage and instill responsible consumption practices. Recycling is an important stage in the Potting's framework, in which components are extracted from discarded items and utilized as inputs for creating new products or processes. It is being proposed to recognize recycling as a mindset, that promotes sustainable lifestyle and living standards. Battery recycling management is crucial for the sustainable development of the electric vehicle ecosystem. Second-life usage after its first lifecycle. Once the battery's performance declines to 70% or below, it enters its 'second life' phase. It can be used as a stationary energy storage system.
	Reuse	Reusing a product not only increases the life span, and durability but also dissuades people from generating waste. It also impacts their production rate and waste generation. It encourages in establishing the second-hand markets and provides employment.
	Remanufacture	Remanufacturing is a comprehensive process. It involves manufacturing goods by using materials from the product replacing its components and redesigning it as per the original standards. In the globalized world, economies need to be self-reliant, and self-sufficient to absorb the external shocks and bounce back to normalcy to ensure continuity and sustenance.
	Refurbish	It is the process of reworking goods and making them look new. This is usually done by thorough system cleaning, repairing any damage, and replacing any dysfunctional parts. This approach increases the durability of the product. The goal is to become a responsible global citizen. It is important to understand being responsible is not a choice but a way of sustainable lifestyle. Responsible behavior is critical for achieving the Sustainable Development Goals (SDGs)

Table 1(a): Determinants mentioned in Red are Author's contribution

4 Results and Discussion

4.1 Technology

The energy storage sector is positioned to have a crucial role in state-level energy planning, to reduce carbon emissions from the electrification and mobility sectors. The widespread adoption of renewable energy sources reaching a solar capacity of 16 gigawatts by the year 2027 is the need of the hour. The integration of energy storage into Uttar Pradesh's power grid is emphasized to ensure faster adoption of electric vehicles by 2030. Furthermore, the current difficulties in managing the high-demand scenario in the state are another important justification for using battery storage. To meet the increasing demand for battery storage, it is necessary to establish local facilities for producing batteries and cells. The manufacturing setup must be supported by sufficient

R&D infrastructure, capacity development, innovation initiatives, incentives and funding, cooperation opportunities, and strategic partnerships.

There is a substantial rise in the demand for advanced cell chemistries (ACCs) and lithium-ion batteries in the state. This is due to the increasing adoption of electric vehicles (EVs) in the transportation system, the integration of Renewable Energy (RE) with the power grid is important for the faster adoption of electric vehicles. Presently, the government of Uttar Pradesh offers numerous incentives to attract investments and promote the domestic manufacturing of batteries and other components within the state. Currently, the industrial environment involves either importing lithium-ion cells from China and assembling them into battery packs within the state or importing pre-assembled battery packs for direct sale to customers. There are multiple battery pack manufacturers operating in the state that cater to the needs of different industries.

The success of the UP EV policy will depend on the sustainable battery manufacturing ecosystem in UP. This policy aims to attract substantial investments throughout the whole value chain. Furthermore, Niti Aayog and other agencies are actively working at the central level to encourage the establishment of large-scale battery production facilities through Advanced Chemistry Cells- Production Linked Incentives (ACC-PLI) [1].

Way Forward
The need is to create a strategic plan/vision document outlining precise goals for battery production to meet the increasing demand. Standardization of DC Charging is needed: There is a lack of standardization and charging communication protocol for interoperability and fast charging for the 2W, 3W, and 4W segments. The recycling process must be developed to offer adaptability in treating different battery compositions and forms.

Table 1(b): Technology Way Forward

4.2 Policy

India's sustainable urban mobility is obstructed by various political and budgetary difficulties. However, these issues are worsened by regulatory gaps that are exclusive to the industry. Various facets of urban transportation are regulated by distinct authorities at the national, sub-national, and local levels. Although it is necessary and required by the constitution to have many bodies overseeing various areas of mobility, such as public transit, air quality, and planning, these institutions and centers of authority do not operate according to a well-defined set of standards. The absence of a comprehensive legislative framework for mobility results in anomalies in the areas of financing, and implementation [6].

Lucknow serves as both the capital and the largest city of Uttar Pradesh (UP). The population of the city is currently 3.85 million and is seeing a consistent annual growth rate of 2.6%. The rapid economic expansion in the state, with a compounded annual growth rate (CAGR) of 8.76%, has resulted in significant growth and an influx of automobiles on the roads. This has put immense pressure on the city's urban transportation system. Lucknow possesses favorable conditions for becoming an EV Lighthouse city. The city's EV sales predictions indicate that there will be over 350,000 electric vehicles on the road by 2030. This will result in a reduction of over 90,000 tons of CO2 equivalent emissions annually [1]. Nevertheless, 11 departments must come together and reach a political consensus to contribute significantly and achieve a higher adoption percentage.

Departments	Way Forward
Housing Urban Development	There are 11 departments for the effective implementation of the electric policy in Lucknow. There is no political coherence between these identified departments. Departments work in silos. The proposed Technology -Polity and Sustainable Framework addresses this gap. Taking a reference from the 12R framework, political acceptance can be achieved through.
Housing and Urban Planning (HoUP)	
Lucknow Municipal Corporation (LMC)	
UP State Construction and Infrastructure Development Corporation (UPSCIDC)	
Lucknow Development Authority	
Public Works Department (PWD)	
Transport Department	
Lucknow Metro Rail Corporation	
UP Pollution Control Board (UPPCB)	
Uttar Pradesh Power Corporation Limited (UPPCL)	
Institute of Entrepreneurial Development (UP-IEDUP)	

Table 1© Source: [1]

4.3 Sustainable

4.3.1 Social

Lucknow the ownership of cars has grown by two-and-a-half times from 2011 to 2022. The annual car registration increased by about 50% from 2013 to 2018, before the pandemic. An increase in individual income and overall economic growth in the city has resulted in a greater percentage of four-wheeled vehicles among the total number of registered vehicles. The National Family Health Survey done between 2019 and 2021 demonstrated that over 50% of households in metropolitan areas own a two-wheeler. The proportion of ride-hailing services and public transportation has increased due to the introduction of ride-hailing applications, the growth of the bus fleet, and the establishment of metro lines around the city. Nevertheless, the utilization of public transportation is rather limited in comparison to other metropolitan areas. Most commuters choose private automobiles, 6-seater Vikram autos, or rickshaws for their daily commute due to the lack of convenient transportation options for the first and last leg of their journey. The city experienced an escalation in the Average Air Quality Index (AQI), which is reported to be > 290, which corresponds to 'unhealthy' and 'very unhealthy' levels. Cars are responsible for 49% of the city's carbon dioxide (CO_2) and carbon monoxide (CO) emissions, as well as 17% of its fine particulate matter (PM 2.5) emissions [1]. The detrimental consequences of pollution are exacerbated by the congestion of roads caused by excessive traffic resulting from the increasing proliferation of vehicles. The repercussions manifest as heightened vulnerability to airborne particles and exhaust fumes. In the present scenario the traditional internal combustion engine (ICE) vehicles will exacerbate greenhouse gas (GHG) emissions, degrade air quality, and intensify the health consequences due to pollution. Considering this, the transition to zero-emission electric vehicles is imperative at present. Electric Mobility is being promoted as a panacea to the environmental risks and hazards.

Table 1(d): Social Way Forward

Way Forward
The people desire to have congestion-free, affordable, sustainable, and clean transportation. Transportation options are progressively becoming the fundamental principles of efficient mobility solutions worldwide. India must implement successful plans to position itself as a prominent catalyst of the global mobility revolution, in line with its dedication to climate objectives. The electrified robust public transportation not only contributes to sustainable urban development but ensures improved air quality. Electric mobility is seen as a promising technology with a great future. The people are seen as ‘consumers’ in the policy. The social benefits need to be incorporated into the policy. The TPSF proposes to incorporate the social requirements.

4.3.2 Economics

The Total Cost of Ownership (TCO) can be used as an assessment tool to assess the adoption of EVs across different segments. It consists of the consumer's overall spending during a vehicle's lifespan, which comprises all costs associated with purchasing, fueling, and maintaining the vehicle. The overall cost during the lifetime is significantly influenced by the operational circumstances, such as the daily usage, maintenance expenses, and the cost of energy or fuel. These factors can be considered as a sequence of cash outflows distributed over several years. The lithium-ion battery packs range between 15% to 40% of the total cost of the electric vehicle. Battery swapping is being seen as a promising technology as it helps to reduce the initial expense by enabling customers to purchase automobiles without batteries. The ownership of batteries lies with swapping station operators, who charge a fixed price or subscription for supplying fully charged batteries that are replaced as they are depleted. This model is preferred by electric rickshaws that have smaller battery capacities. It allows them to run continuously throughout the day with very little time spent on charging. Nevertheless, the cost of batteries is decreasing as technology progresses. Efficient and cost-effective battery charging solutions are critical for faster adoption of electric vehicles. Traditional charging technology is time-consuming. Although this method is convenient for individual users, but inefficient for larger-scale applications, such as commercial fleets or public transportation systems [1]. In his study, Yongzhong Wu postulated that battery-swapping technology results in substantial cost reductions when compared to conventional charging methods [8]. The study revealed that the battery swapping technology reduces the TCO of the electric vehicle by 25%. In the study conducted by the National Renewable Energy Laboratory (NREL), it is being postulated that the battery swapping technology is efficient for commercial fleets. It has the potential to save operational expenditures by up to 30% for electrified trucks and vans.

Despite all the potential economic benefits, the widespread adoption of swapping technology is hindered due to the lack of standardization across the entire charging ecosystem. The initial cost to construct a network of battery swapping/charging stations is significantly exorbitant, thus dissuading governments and business entities from mass adoption. Nevertheless, with the increasing demand for Electric Vehicles (EVs) and the urgent requirement

for charging solutions that are both efficient and cost-effective, the use of battery-swapping technology may become more prominent.

Ultimately, although traditional battery charging technology is currently the predominant approach in the electric vehicle (EV) business, battery swapping technology presents a viable option that has the potential to decrease the entire cost of owning and operating EVs. To meet the growing need for environmentally friendly transportation options, it is essential to investigate and fund cutting-edge technologies that can address the barriers related to battery charging and facilitate the wider use of electric vehicles [1]

Way Forward
Due to limited manufacturing facilities for Li-ion batteries in the country, the workforce has limited expertise that can be utilized in future facilities. Consequently, significant time and effort will be needed for them to acquire new capabilities to cultivate a proficient workforce in fields associated with mineral extraction, processing, refining, and recycling.
In terms of finance, the government needs to shift focus on enhancing the capabilities of local banks and important financial institutions in the state. This will help to decrease the perceived risk and improve lending conditions, such as interest rates, collateral requirements, and the whole evaluation process for loans related to battery storage manufacturing.
Electric Mobility has the potential to improve the standard of living and overall well-being of the residents while generating job opportunities through the 'Make-in-India' initiative, which covers a wide spectrum of skill sets. Financial incentives and tax breaks are needed to bolster the adoption.

Table 1(e): Economics Way Forward

4.3.3 Environment

The management and recycling of batteries are of paramount significance in the electric mobility ecosystem. The manufacturing of batteries results in a substantial quantity of discarded material, that must be appropriately managed and recycled to minimize the potential emission of dangerous poisonous gases into the environment. Failure to appropriately manage the growing quantity of battery waste may result in the disposal of these batteries in landfills, hence posing environmental risks. The economic viability of recycling batteries is mostly determined by battery chemistry, assuming that the recovery efficiency is complete. Despite being widely utilized, LFP battery chemistry does not offer attractive profit margins for recyclers due to its reduced economic value and high recycling expenses. In addition, LFP does not include any precious metals other than lithium, which is found in a minimal amount. Hence, recyclers must customize their procedures to enhance plant efficiency and the capacity to handle a diverse array of battery compositions [1].

For instance, the waste from lithium-ion batteries has the potential to be absorbed and accumulate in edible plants, ultimately entering the food chain. This can lead to a range of issues, including genetic abnormalities, reproductive problems, and gastrointestinal disorders. Furthermore, the state's increasing demand for batteries is expected to lead to a significant increase in the requirement for raw materials and essential battery minerals. For an electrified future, it is imperative to ensure sustainable production and consumption of natural resources (rare earth metals in this case) which is critical for manufacturing the lithium-ion battery packs for electric vehicles. In India, recycling technologies are limited. The recycling of lithium-ion batteries is mostly carried out using two methods: 'end-to-end recycling' and 'mechanical extraction of black material'. End-to-end recycling involves the player taking full responsibility for all operational aspects of the recycled product. The adoption of this approach in India is limited due to regulatory and demand difficulties, as well as technological constraints. However, the market is expected to transform with the emergence of substantial players [1]. Another method of recycling lithium-ion batteries in India involves extracting black matter through a mechanical process known as 'dismantling'. In this procedure, the companies collect spent batteries from both organized and unorganized sectors. They then employ a mechanical method to extract the black mass, which involves separating aluminum, cobalt, and plastic components from the other materials, resulting in a black mass. They subsequently transmit it to other major corporations that possess advanced technology for extracting minerals from the black mass or transporting it to their centralized hub in distant nations.

Presently, the prominent entities involved in the recycling of batteries and electronic waste in India either engage in illicit activities or cease their operations after extracting only 2-3 types of metals. Given that Uttar Pradesh has the highest electric vehicle (EV) sales in India in 2023, it is crucial to establish a robust recycling system in the state. This will help determine the potential resale value of batteries for reuse or recycling purposes. The collecting and recycling of Li-ion batteries at the end of their first life cycle can be harnessed through second-life

applications. By establishing a secondary market for electric vehicle (EV) batteries it would enhance the allocation of funds for electric vehicles (EVs), hence promoting the uptake of EVs. Consequently, there is a growing need for a circular economy in the recycling and reuse of battery components.

Way Forward
The government should assist in establishing battery disposal and recycling facilities near charging stations.
The government's efforts (funds, functionaries, and finance) are critical in establishing collection sites for end-of-life batteries at dealerships, in collaboration with battery manufacturers and the UP-Pollution Control Board (UPPCB), to facilitate battery recycling at these centers.
A policy promoting sustainable battery recycling technology is needed at the state level to attract more investors in the battery recycling and reuse industry.
The battery materials extracted from the recycling process should be utilized and reused in various secondary industries like as aviation, pharmaceuticals, ceramics, cement, and others.
Waste Handling regulations standardization missing, Policy intervention is needed

Table 1(f): Environment Way Forward

5. Conclusion

India committed to the Clean Transport Breakthrough at the 2021 United Nations Climate Change Conference (COP 26). The objective of this initiative is to make zero-emission vehicles (ZEVs) the standard mode of transportation by 2030, ensuring their availability, affordability, and sustainability in all areas. India committed to vigorously promoting and embracing the rapid spread and use of Zero Emission Vehicles (ZEVs). During the 4th ministerial discussion of the Zero Emission Vehicles Transition Council (ZEVTC), NITI Aayog expressed its endorsement of the non-binding declaration and COP26 agreement, which aims to expedite the global transition to zero-emission vehicles (ZEVs).

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Conflict of interest:
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References

[1] Asian Development Bank, "Lucknow Comprehensive Electric Mobility Plan," Nov. 2022. [Online]. Available: https://invest.up.gov.in/wp-content/uploads/2023/06/CEMP-Lucknow-Report_PWC_Final_Lowres-1.pdf

[2] Briefing, "India's EV Production Capacity and Domestic Auto Market Trends," *India Briefing News*, Mar. 26, 2024. https://www.india-briefing.com/news/indias-prospects-as-an-ev-hub-consumer-market-and-production-capacity-30157.html/#:~:text=Key%20takeaways,manufacturers%20to%20achieve%20COP26%20goals.

[3] J. Neubauer and E. Wood, "The impact of range anxiety and home, workplace, and public charging infrastructure on simulated battery electric vehicle lifetime utility," *Journal of Power Sources*, vol. 257, pp. 12–20, Jan. 2014, doi: 10.1016/j.jpowsour.2014.01.075.

[4] K. Kumar and K. Kumar, "Top 10 states with the highest EV adoption rate (Ranked)," *Zecat - Experience EVs*, Dec. 12, 2023. https://zecat.in/top-10-states-with-the-highest-ev-adoption-rate-ranked/

[5] M. Gupta, "Uttar Pradesh Achieves An 18% Surge In Electric Vehicle Sales, Leading The Way In India's EV Revolution In 2023," *EMobility+*, Jan. 09, 2024. https://emobilityplus.com/2024/01/09/uttar-pradesh-achieves-an-18-surge-in-electric-vehicle-sales-leading-the-way-in-indias-ev-revolution-in-2023/#google_vignette

[6] M. Patankar, I. Prem, MP Ensystems Advisory Private Limited, and Shakti Sustainable Energy Foundation, "Urban Mobility Regulatory Reforms in India," MP Ensystems Advisory Private Limited, report, 2019. [Online]. Available: https://static1.squarespace.com/static/62612a6a875eaa3537786668/t/62668e6d45ee9d075540dd25/1650888327501/Urban+Mobility+Regulatory+Reforms+in+India.pdf

[7] Society of Indian Automobile Manufacturers, "Adopting Pure Electric Vehicles: Key Policy Enablers," Dec. 2017. [Online]. Available: https://www.siam.in/uploads/filemanager/114SIAMWhitePaperonElectricVehicles.pdf

[8] Y. Wu, S. Zhuge, G. Han, and W. Xie, "Economics of Battery Swapping for Electric Vehicles—Simulation-Based Analysis," *Energies*, vol. 15, no. 5, p. 1714, Feb. 2022, doi: 10.3390/en15051714.