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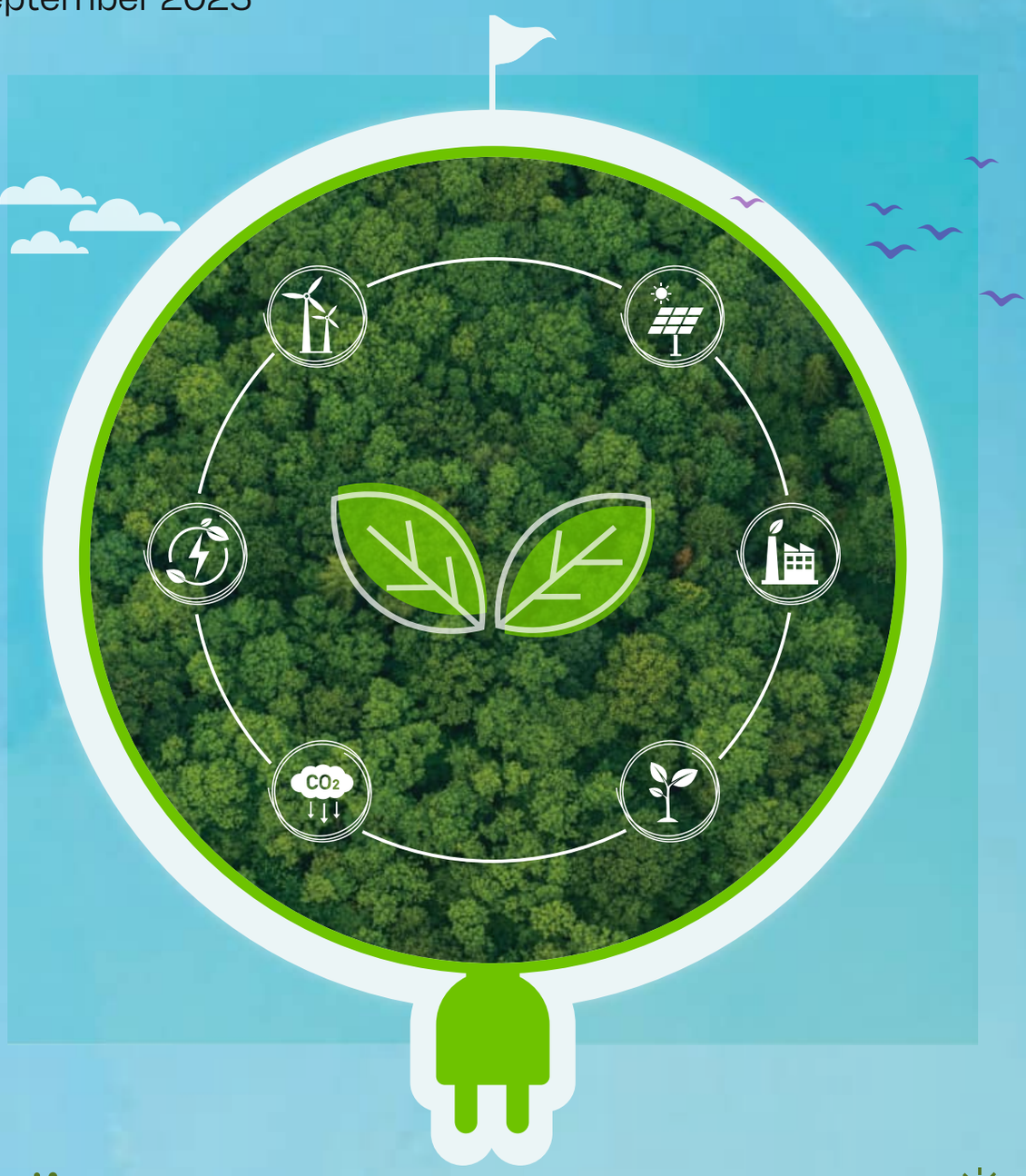
BACKGROUND PAPER

SIAM
Society of Indian Automobile Manufacturers

Opportunities for India to Leverage Sustainable Mobility

September 2025



Acknowledgments

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SIAM thanks the many people who have shaped and contributed to the insights we share here, including our knowledge partner, McKinsey & Company, for providing the analytical fact base.

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Preface

India aims to reach net-zero greenhouse gas emissions by 2070, a goal announced at the UN Climate Change Conference, 2021 (COP26). This necessitates transformative changes across various sectors, including the development of sustainable alternatives in transportation. As the country progresses towards this goal, sustainable mobility has become essential for reducing the carbon footprint, increasing energy independence, and improving urban air quality.

This report proposes various avenues that could support and accelerate India's progress in the quest for a robust and resilient ecosystem toward greater sustainable mobility. The development and adoption of alternative powertrains, such as electric and hydrogen vehicles, is central to reducing emissions. India is investing in advanced battery technologies and localizing the production of critical components to mitigate geopolitical risks and create local job opportunities. Shared mobility solutions, such as ride-sharing and bike-sharing, can significantly reduce congestion and emissions in urban areas. Additionally, promoting circular business practices, such as vehicle lifecycle management and the use of bio-based materials, can further reduce carbon emissions and resource consumption.

Integrating these pathways can help India create a more sustainable and efficient transportation system that supports its net-zero ambitions and contributes to global efforts to combat climate change.

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The global landscape of sustainable mobility

Sustainable mobility refers to a holistic approach to transportation that prioritizes environmental sustainability, economic viability, and social equity. This means adopting cleaner and more efficient technologies, promoting public and non-motorized transportation, and implementing policies that encourage sustainable practices. The foundations for such a holistic approach are emerging worldwide, with the potential to shape a greener, more efficient transportation system—driven by both the socio-economic necessity and the environmental imperative.

Alternative powertrains, including battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen-based powertrains, are transforming the automotive landscape. Despite challenges such as subsidy reductions and trade uncertainties, consumer sentiment towards these technologies remains strong, driven by their environmental benefits and advancements in battery technology.

Shared mobility is another cornerstone of sustainable transportation, offering a viable solution to reduce traffic congestion and emissions. With the rise of ride-hailing services and bike-sharing systems, cities worldwide are implementing tailored interventions to promote the adoption of shared mobility.

Raw material shortages and tighter environmental regulations are driving a greater thrust on material circularity, with the automotive sector focusing on recycling and reuse. Circular practices could help the industry to substantially reduce its carbon footprint and create a more sustainable value chain.

Alternative powertrains: Sustained optimism for electrified powertrains, emerging success for others

Alternative powertrains encompass multiple fuel types, with electrified powertrains being the most prevalent. The global electric vehicle industry has experienced several fluctuations over the years, and Gartner's Hype Cycle framework is helpful to understand this evolution.[1] This model outlines the journey of new technologies such as EVs, starting from the initial innovation triggers, to rising excitement, followed by a phase of broader adoption wherein certain limitations to mass-scale adoption become apparent (the current state of the industry), and finally reaching a stage where the technology matures and achieves widespread practical adoption.

The first mass-market electrified vehicles were launched in 2010, followed by the introduction of premium ones in 2012. The industry saw a peak in 2018 when electrified vehicles became the top luxury cars in European markets, and by 2019, over 50 percent of vehicle sales in Norway were electric.[2]

1 Gartner hype cycle, Gartner.
2 Bilsalget i 2019 [Car sales in 2019], Opplysningsrådet for Veitrafikken [Norwegian Road Federation] (OFV).

In the early 2020s, the global EV industry faced some roadblocks in scaling up, with delayed diesel bans in Paris and postponed ICE bans by markets such as the United Kingdom[3] and customers' skepticism about the adequacy of public charging networks and the residual value of EVs.

Despite these challenges, the fundamentals of the EV market remain strong, with expectations of more localized battery and EV production, improved profitability for at-scale players, expanded and higher-quality charging networks, and cheaper, larger, and faster-charging batteries by 2030.[4]

The positive outlook for EVs is reflected in the growing global consumer spend on EVs even with reduced subsidies (Exhibit 1), pointing to a maturing ecosystem and a rise in consumer confidence. In 2024, global consumer spending on EVs exceeded $500 billion, almost $200 billion higher than that in 2022.

In the United Kingdom, for example, even though EV purchase subsidies were gradually reduced in 2022, sales continue to rise steadily. Sales growth has been further supported by initiatives such as the Vehicle Emissions Trading Schemes, which mandate zero-emission car sales targets starting in 2024. The country also offered tax concessions for fleet cars, which accounted for approximately 60 percent of total car registrations in 2024.[5] Following the removal of EV grants, the government has prioritized investments in EV charging infrastructure and encouraged OEMs to lower EV costs.

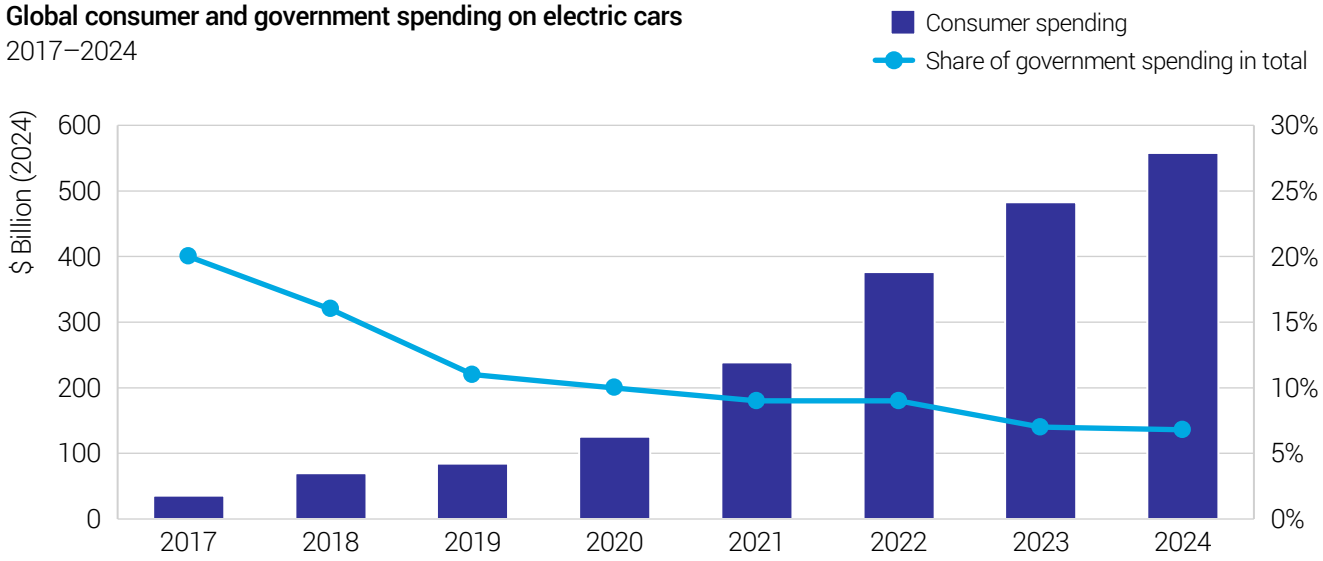
In Germany, EV sales declined after subsidies were discontinued in late 2022–23. However, new tax incentives and EV technology improvements are set to accelerate electrification. The German government's new tax benefits for electric fleet cars, effective from July 2024 through 2028, are expected to revive the momentum in EV sales. Additionally, the government has introduced measures to enhance the attractiveness of EVs, such as expanding charging infrastructure and providing incentives for the development of battery technology. These efforts are expected to create a more favorable environment for the adoption of EVs, and contribute to the overall growth of the market.

[3] Natalie Middleton, "UK Government Confirms Five-Year Delay to 2030 ICE Ban" EV Fleet World, September 20, 2023.
[4] Yuri Kageyama, "Nissan says it will make next-generation EV batteries by early 2029," Associated Press, April 16, 2024.
[5] David Leggett, "UK 2024 Car Market Falls Just Short of 2 Million," Just Auto, January 6, 2025.

Exhibit 1

Consumer spending on alternative powertrain vehicles is rising globally, suggesting that subsidies are not the sole driver for sales

Global consumer and government spending on electric cars
2017–2024



Source: IEA Global EV Outlook

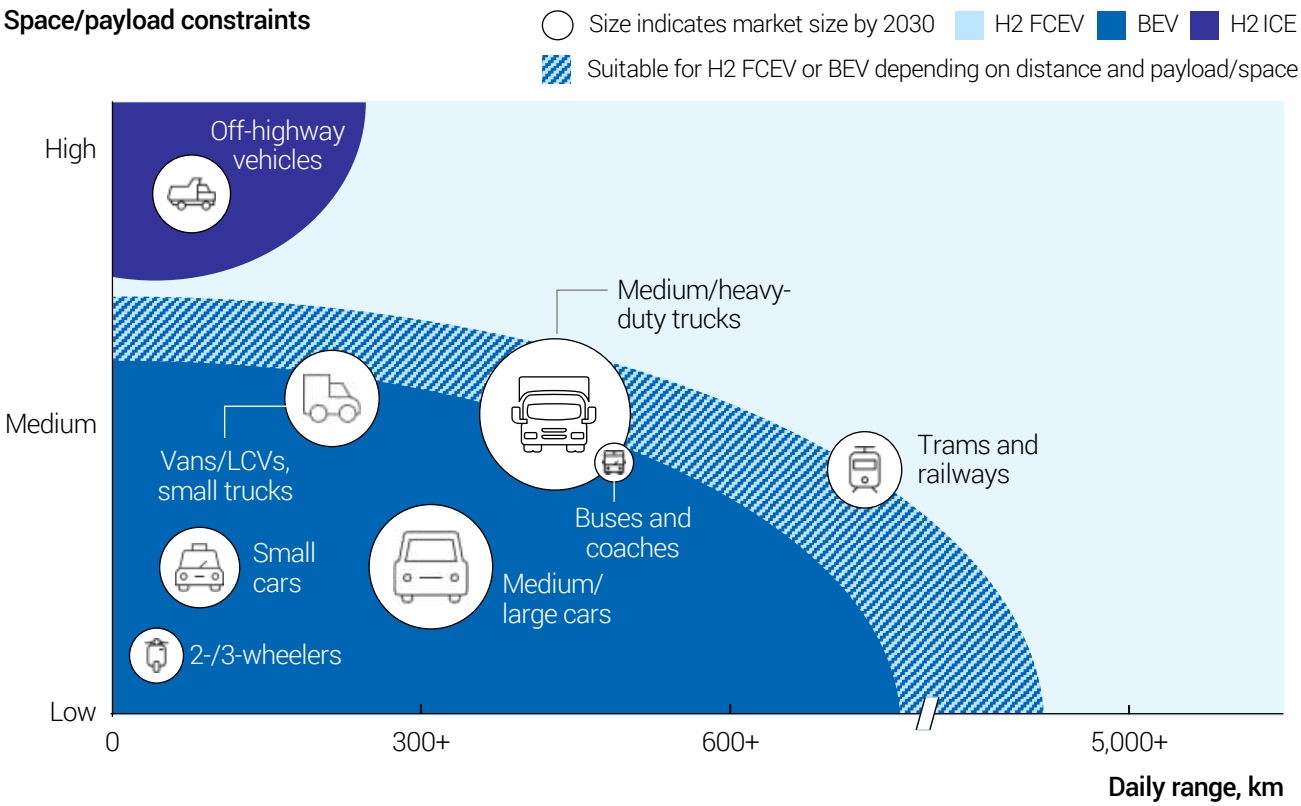
Despite such challenges, alternative powertrains enjoy healthy consumer sentiment,[6] with over 40 percent of global four-wheeler buyers considering battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) for their next purchase, and 62 percent considering electric two-wheelers (E2Ws) for their next two-wheeler purchase. This positive sentiment is driven by factors such as lower operating costs, environmental benefits, and advancements in battery technology.

Market-specific factors continue to dictate the evolution of powertrains across the world. For instance, hydrogen-based powertrains such as fuel cell electric vehicles (FCEVs) and hydrogen internal combustion engines (H2 ICE) have shown promise for long-haul and off-highway applications (Exhibit 2). Each powertrain offers distinct advantages based on the use case, with FCEVs being particularly suitable for long-haul applications requiring large batteries and H2 ICEs well-suited for applications with high payload and low range requirements.

[6] Mobility Consumer Pulse 2025, Annual survey by McKinsey Center for Future Mobility, global N = 25,904, India N = 2,743.

Exhibit 2

Hydrogen-based powertrains, especially H2 FCEV and H2 ICE, have shown distinct advantages for long-haul and off-highway applications



Role of Zero-emission vehicle (ZEV) technology

Long-haul: H2 FCEV

Key technology next to BEV (TCO differ by less than 10% starting 2035), especially HDT and long-haul use cases requiring large batteries

Relatively mature: BEV

Dominating technology with more mature infrastructure and models especially MDT, LDT, and LCV segments

Application-specific tech: H2 ICE

Significantly lower emissions than gasoline/diesel/natural gas-based ICE; suitable for applications with high payload and low range requirements

Source: IEA ETP; IHS; A Portfolio of Powertrains for Europe (2010); Thiel (2014); Hydrogen Council

Shared mobility: Large-scale adoption necessitating region-specific interventions

The penetration of shared mobility has been rising at a rate of 3 to 4 percent globally, with over 65 percent of people having access to at least one shared mobility mode on average.[7] Travel requirements, road conditions, safety, and other factors determine the mode of choice, shaping unique shared mobility ecosystems in different cities.

Improving shared mobility adoption and deciding on the modal mix (for example, more micromobility and less ride-hailing) requires establishing a vision with key actions and targets. For instance, Paris aims to become a "15-minute city" by 2030, where residents can meet essential needs within a 15-minute travel distance from their homes (Exhibit 3). This vision includes measures such as systematically reducing parking spaces, phasing out ICE vehicles by 2030, and integrating bike-sharing systems with public transport.

Other cities including Amsterdam[8] and Oslo,[9] have also implemented tailored interventions to encourage higher uptake of shared mobility. These measures include expanding cycling infrastructure, reducing car traffic, and investing in public transport networks such as metro and tram expansions. Amsterdam has set up over 700 km of dedicated bike lanes and over 10,000 bike parking spots, targeting more than 90 percent modal share for shared mobility and micromobility by 2030. Similarly, Oslo has reduced car traffic in the city center by making it car-free since 2019.

7 Mobility Consumer Pulse 2025, Annual survey by McKinsey Center for Future Mobility, global N = 25,904, India N = 2,743.

8 "Perspectives on the future of mobility in Amsterdam," City of Amsterdam and Amsterdam Smart City, March 26, 2018; "Building a truly bike-friendly city: Lessons from Amsterdam, "Urban Land Institute, 2017; "Amsterdam to ban diesel and petrol vehicles by 2030, "Global Parliament of Mayors, May 8, 2019; "Policy: Public transport," City of Amsterdam, accessed on February 25, 2025; "Innovatie: Amsterdam Smart City" (Innovation: Amsterdam Smart City), City of Amsterdam, accessed on February 25, 2025.

9 Oslo (Norway), "CIVITAS, accessed on February 25, 2025; "Climate strategy for Oslo towards 2030," C40 Cities Climate Leadership, June 2020; Jonathan Wolfe, "Oslo puts up a stop sign," New York Times, December 19, 2018; Eurocities, "Integrating micromobility into Oslo's public transport," Cities Today, April 2, 2025.

Exhibit 3

Boosting shared mobility adoption demands region-specific strategies, exemplified by targeted actions in Paris

Interventions for encouraging higher shared mobility uptake in Paris

Objective

Enhance sustainability and accessibility in the mobility ecosystem

Vision

A "15-minute city" by 2030, where residents access essential needs within 15 minutes of their homes

Measures taken and outcomes

- Systematic reduction of parking spaces
- Phasing out ICE vehicles by 2030
- Integration of bike-sharing systems with public transport
- Metro and tram network expansion

Source: 15-minute city: 2021-2022 finalist, Prize for Cities, accessed 2025; Feargus O'Sullivan, Paris to replace parking spaces with trees, Bloomberg, November 12, 2024; Frédéric Simon, Dan Lert: The City of Paris aims to phase out diesel by 2024, and thermal cars by 2030, Euractive, June 20, 2022; Ron Johnson, Paris Olympic bicycle revolution: Lessons for Los Angeles and other global cities, Momentum Mag, January 15. 2025; Xiaofei Xu, "Paris is getting a whole new Metro network. And it's huge," CNN, December 5, 2023

Material circularity: Growing demand for recycled materials as virgin resources shrink and prices climb

Strong market forces are driving the global automotive sector towards circularity. For example, material circularity practices such as recycling can help OEMs circumvent supply shortages of low-carbon materials (e.g., flat steel, plastics) and lock in prices (Exhibit 4). Recycled materials also require considerably less energy than virgin production, reducing energy consumption by up to 95 percent for aluminium.[10]

Cooperation between players in the value chain is becoming increasingly essential to address circularity challenges and meet CO2 targets. Policies and regulations in the European Union, such as the End-of-Life Vehicle (ELV) directive and the EU Green Deal, are strong drivers of circularity. The ELV directive, for example, mandates that 95 percent of a vehicle's weight must be reused or recycled, leading to increased investment in recycling technologies and infrastructure.

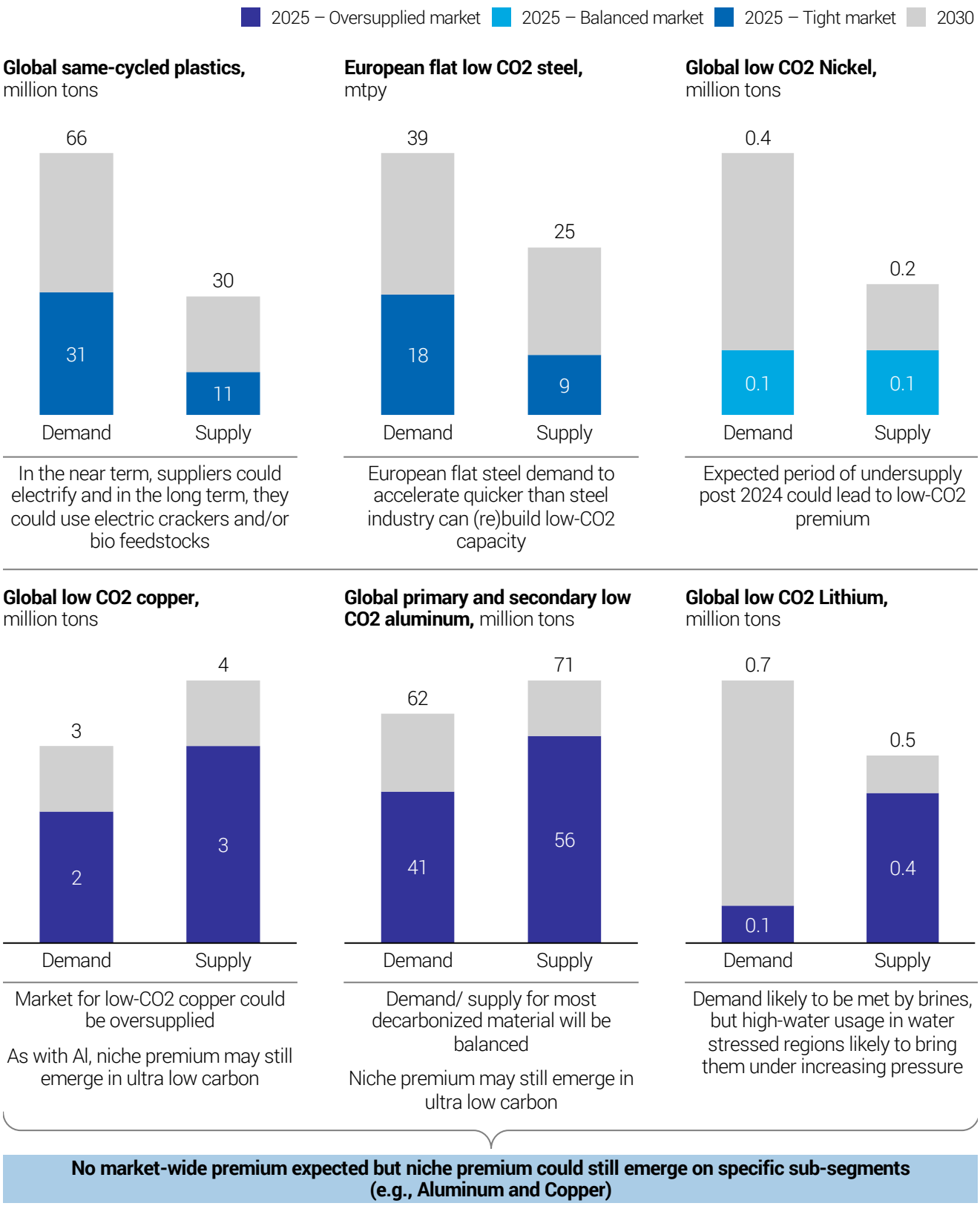
The business case for shifting to recycled materials has improved significantly over the past few years, driven by high and volatile prices for primary materials and the rise in CO2 prices. This shift is further supported by the increasing number of externally communicated circularity goals from OEMs, which strengthens their ESG value proposition and enhances their overall business case.

Sustainable mobility is gaining traction globally, led by the continued growth of electrified powertrains as the primary alternative to traditional engines. The success of shared mobility depends on a localized approach to encourage widespread adoption. Meanwhile, material circularity is on the rise as recycled materials become popular due to the rising cost and shrinking supply of new resources.

[10] "Aluminium Recycling Saves 95% of the Energy Needed for Primary Aluminium Production." International Aluminium Institute.

Exhibit 4

When low-carbon materials (e.g., flat steel, plastics) are in short supply, recycling can help OEMs be resilient and lock in prices



Source: McKinsey Basic Materials Practice: McKinsey Battery Demand Model, Recycling Partnership Plastic Recycling Report, S&P Global; McKinsey's sustainable materials hub base case + scenarios


CONCEPT

02

India's progress in sustainable mobility

Consumers are now leading the charge for sustainable mobility. A recent McKinsey India Mobility Consumer Survey[11] found that sustainability is the top purchasing criterion for Indian consumers buying their next private vehicle: 73 percent of Indians have either changed or are in the process of changing their consumption habits due to sustainability concerns. Further, over 25 percent of respondents expressed loyalty to sustainable brands, over 20 percent engaged in advocacy for sustainable products, and over 20 percent frequently tried sustainable offerings. As a result, the industry has a growing incentive to shift toward sustainable mobility solutions.

Alternative powertrains: A deepening relationship

India's adoption of alternative powertrains has grown notably over the past five years, driven by better economics, positive consumer sentiment, and improved infrastructure. Alternative powertrain penetration varies across different vehicle segments, with two-wheelers and three-wheelers registering the highest levels. This growth has been facilitated by the improving total cost of ownership (TCO) of such vehicles compared to ICE vehicles, as well as a greater variety of product options available to consumers. For instance, the market for electric two-wheelers and three-wheelers has grown substantially, driven by the high demand for affordable and efficient urban mobility solutions (Exhibit 5).

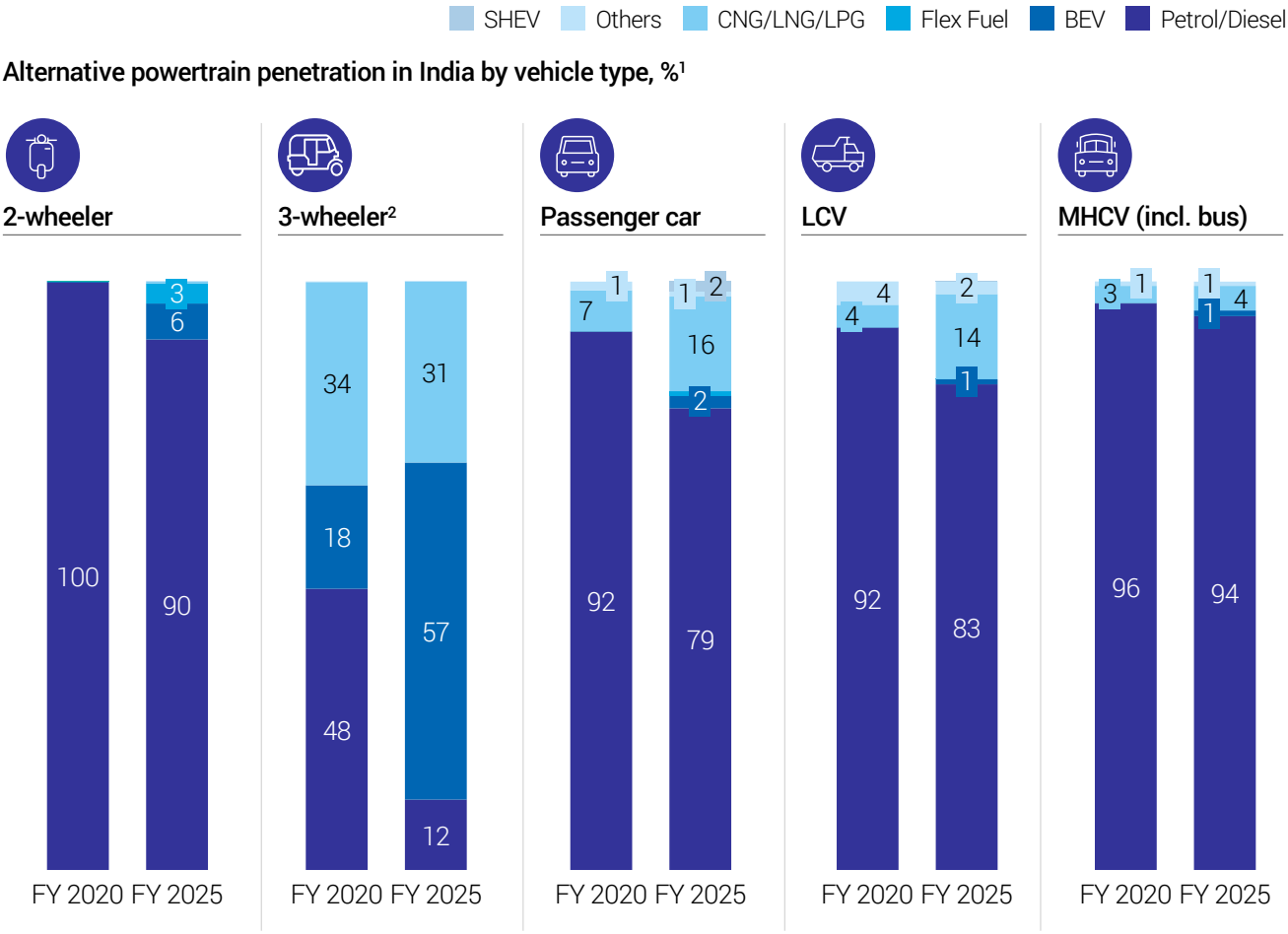
In contrast, passenger vehicles (PVs) have recorded comparatively lower EV penetration due to the higher cost difference and lack of demand incentives. The commercial vehicle segment has seen the slowest EV uptake (approximately 1 percent overall, with 4 to 5 percent penetration in buses), mainly due to fewer product options and limited charging infrastructure along highways.

There is a steady rise in CNG or bi-fuel powertrain adoption in passenger cars and light commercial vehicles, driven by a combination of cost economics, infrastructure, policy, and OEM strategy. CNG offers a per-kilometer operating cost up to 20 percent lower than petrol or diesel, making it an advantageous option for savings amid elevated liquid fuel prices.[12] The refueling network expanded rapidly, reducing range anxiety and improving accessibility. Government support through accelerated city gas distribution rollouts, tax concessions in key states, and restrictions on diesel vehicles in polluted urban centers further incentivized adoption. OEMs have also responded by broadening their portfolio, with the number of available CNG car models more than doubling since FY 2021.[13] Although CNG variants carry an upfront premium over petrol models, they offer a favorable return on investment for high-mileage users.

[11] Mobility Consumer Pulse 2025, Annual survey by McKinsey Center for Future Mobility, global N = 25,904, India N = 2,743.
[12] "IOA2021. "How Much CNG Cost Per KM? {Calculators Inside}." IOAGPL, April 9, 2025.
[13] Ajit Dalvi," CNG car sales grow 97 percent in April-September 2021," Autocar India, November 9, 2021; CNG cars in India, CarDekho, accessed on September 3, 2025.

Exhibit 5

India's alternative powertrain market is expanding, driven by better economics and improved infrastructure



1. The totals might not add to 100% because of rounding
2. Includes e-rickshaws
Source: Vahan

The Indian government's promotion of alternative powertrains has been instrumental in driving their adoption. Policies such as the PM E-DRIVE and erstwhile FAME schemes, which provide financial incentives for the purchase of electric vehicles and the development of charging infrastructure, have played a crucial role in making EVs more accessible and affordable.[14] Similarly, India has also made remarkable progress in its ethanol blending program, achieving the E20 target five years ahead of the original 2030 deadline.[15]

Four factors contribute to the adoption of alternative powertrains in India:

Favorable economics: The declining prices of batteries and the rising costs of ICE fuels have made alternative powertrains, especially electrified powertrains, more economically viable despite the reduction or discontinuation of purchase subsidies. For instance, the total cost of ownership for an electric passenger car is on par with an ICE car. This is because the average price of EV battery packs has declined over time, driven by rapid technological innovation and reductions in raw material costs. In FY 2020, the average cost of an EV battery pack was approximately $180 per kWh, and it fell to approximately $110 per kWh by FY 2025,[16] making EVs more affordable for the average consumer. This reduction in battery costs is primarily due to advancements in battery chemistry, economies of scale in battery production, and improved manufacturing processes. The rising prices of fossil fuels have further shifted the economic balance towards EVs and CNG vehicles.

Rising consumer sentiment: Consumer intent to switch to EVs is notably high in India. According to the McKinsey India Mobility Consumer Survey,[17] approximately 80 percent of Indian two-wheeler buyers plan to switch to electric, higher than the global average. This trend is also evident among four-wheeler buyers, especially younger and urban consumers, who show a high consideration for BEVs for their next purchase. This shift in consumer sentiment is driven by growing awareness of environmental concerns and the desire to reduce carbon footprints. Additionally, the growing availability of a diverse range of EV models, from affordable two-wheelers to premium electric cars, has made it easier for consumers to find an EV that suits their needs and budget. The Indian automotive market has witnessed the entry of several new players, both domestic and international, offering innovative and competitively priced electric vehicles. The rise of social media and digital platforms has also played a significant role in spreading awareness about the benefits of EVs and influencing consumer preferences.

Refueling/Energy infrastructure expansion: The rapid expansion of India's public EV charging infrastructure has played a significant role in light vehicle electrification. The current network of 26,367 operational charging stations as of March 31, 2025,[18] represents remarkable growth—exceeding 50 percent CAGR since fiscal year 2022—driven by three key factors: increased consumer awareness, a wider range of EV products, and favorable usage economics. While India's charging network density is currently at par with leading EV markets globally (Exhibit 6), it will require a significant boost to keep pace with rising EV penetration. So far, this infrastructure development has been focused on urban and high-traffic areas. However, comprehensive adoption of electric powertrains would require further infrastructure investments that extend into rural regions.

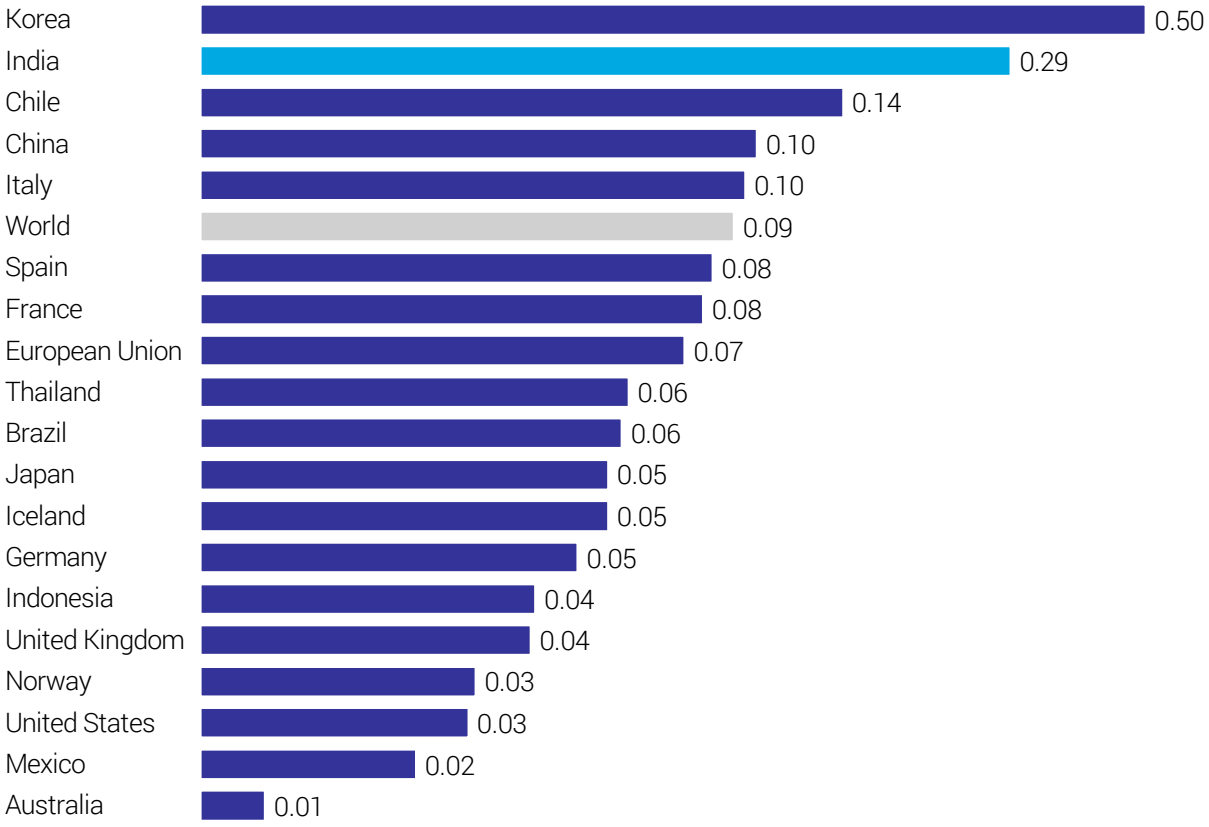
India's CNG refueling infrastructure has also seen growth over the last five years. The number of CNG fuel stations increased from 2,187 in March 2020[19] to 8,205 in August 2025,[20] driven by the popularity of CNG-based bi-fuel passenger vehicles.

[14] ETAuto Desk, "Over 18.8 lakh EVs supported under FAME schemes till June 2025: Govt.," ETAuto, July 23, 2025.
[15] TOI Business Desk, "India hits 20% ethanol blending target 5 years early; big jump from 1.5% in 2014: Report," The Times of India, July 25, 2025.
[16] "Electric vehicle battery prices are expected to fall almost 50% by 2026," Goldman Sachs, October 7, 2024.
[17] Mobility Consumer Pulse 2025, Annual survey by McKinsey Center for Future Mobility, global N = 25,904, India N = 2,743.
[18] "Target set for installing of EV charging stations and implementation of FAME-III," Ministry of Heavy Industries press release, April 4, 2025.
[19] Yuthika Bhargava, "CNG Set to Be 2nd Most Popular Fuel for Passenger Vehicles in India by 2027, Says ICRA Report." The Print, April 17, 2023.
[20] Petroleum Planning & Analysis Cell, Ministry of Petroleum and Natural Gas, Government of India.

Exhibit 6

India's charging network density appears adequate given relatively low EV adoption; significant infrastructure investment would be needed to sustain parity as electrification accelerates

Number of public charging points[1] per electric light-duty vehicle[2], 2024



1. Includes fast (DC) and slow charging points
2. Includes cars and vans
Source: IEA Global EV Outlook 2025

New use cases: Applications such as last-mile deliveries and ride-sharing have emerged as particularly relevant for BEVs in India, spurring new form factors such as e-rickshaws, minimobility vehicles, and e-scooters. These use cases are also seeing growth due to factors like rapid urbanization, government initiatives including smart cities, and the rise of smartphones, apps, and digital payments. The e-commerce boom in India has further accelerated the demand for electric delivery vehicles, with major companies committing to transitioning their delivery fleets to electric by 2030.[21] The rise of ride-sharing platforms has also contributed to the growth of EVs, as these companies are increasingly incorporating EVs into their fleets to reduce operational costs and meet sustainability goals. Additionally, the development of new business models, such as battery swapping and subscription services, has made it easier for consumers and businesses to adopt EVs without the need for considerable upfront investments. The government has also introduced various policies and incentives to promote the use of EVs in public transportation and commercial applications, such as exemptions from road taxes and registration fees, and subsidies for the purchase of electric buses and commercial vehicles.

[21] Sreeradha Basu and Brinda Sarkar, "Driving change: Ecomm firms amp up for sustainable future," The Economic Times, June 29, 2025.

Shared mobility: Accessible mobility for all

Urban India has seen an encouraging and healthy adoption of shared mobility and public transit options. The share of metro and ride-hailing services has risen in urban mobility. Metro's share of passenger kilometers traveled in metropolitan areas like Delhi has risen from less than 5 percent in the late 2000s to over 20 percent presently.[22] Increased income levels, urban density, and significant commitments to infrastructure development drive this shift.

While Indians have begun to shift towards privately owned, motorized transport options as their incomes increase, the overall sentiment towards shared mobility remains positive. Despite challenges such as service reliability, lack of integration with public transit, and profitability, approximately 47 percent of all Indians are willing to adopt a sustainable lifestyle by opting for shared mobility versus 35 percent people globally.[23]

Material circularity: Reducing resource usage

The Indian government has introduced several policies aimed at promoting circularity in the automotive sector, including vehicle scrappage programs, e-waste management rules, and extended producer responsibility (EPR) policies:

1. Vehicle scrappage policies

The government-funded vehicle scrappage program[24] aims to phase out aging and polluting vehicles from the roads and replace them with modern, fuel-efficient cars. The policy requires that commercial vehicles older than 15 years and private vehicles older than 20 years be scrapped if they fail to pass fitness tests. The program incentivizes participation by giving scrapped vehicle owners residual value for the old vehicle, discounts on the purchase of new vehicles, and waivers on registration fees. This dual-benefit approach not only reduces vehicular emissions, but also boosts the automotive industry. Simultaneously, the scrappage policy is expected to generate employment opportunities in the recycling and manufacturing sectors, contributing to economic growth.

2. E-Waste EPR policies

The EPR policy[25] requires that all waste batteries be collected and sent for recycling or refurbishment. It prohibits the disposal of batteries in landfills and their incineration, ensuring the environmentally sound management of batteries at the end of their life. Producers are required to establish collection centres and take-back systems to facilitate the return of used batteries. The policy also highlights the crucial role of public awareness campaigns in educating consumers on the importance of proper battery disposal. By promoting recycling or refurbishment, it supports the reuse of valuable materials from recycled batteries for new battery production. This results in a reduction of the demand for finite virgin raw materials.

3. Tyre EPR policies

Tyre producers are required to ensure the environmentally sound management of waste tires. The EPR[26] obligation includes recycling 100 percent of tyres by 2025. Producers are required to set up collection points and collaborate with authorized recyclers to ensure that waste tyres are processed in an efficient, ethical, and transparent manner. The policy also promotes circularity by utilizing recycled rubber in the production of new tyres. The initiative opens up new value streams, as materials recovered from recycled tyres can be used to make roads, sports surfaces, and industrial products.

22 RITES 2007, DIMTS 2018, TUMI E-Bus Mission 2022.
23 Mobility Consumer Pulse 2025, Annual survey by McKinsey Center for Future Mobility, global N = 25,904, India N = 2,743.
24 "Vehicles Scrappage Policy Launched: All Rules and Benefits Explained in 6 Points." India Today, August 13, 2021.
25 "Government notifies battery waste management rules, 2022," Ministry of Environment, Forest and Climate Change press release, August 25, 2022.
26 Rupin Chopra, Raj Kumar Gupta, "Extended producer responsibility (EPR) For waste tyre," Mondaq, September 20, 2022.

4. Battery waste management rules

The battery waste management rules[27] require at least 90 percent of materials to be recovered by 2027 and specify that new batteries must contain at least 5 percent recycled materials within the same timeframe. The rules also require that battery manufacturers label their products with information on disposal and the ecological risks associated with improper disposal. Manufacturers are also encouraged to design batteries that are easier to disassemble and recycle, thereby enhancing the efficiency of the recycling process. The implementation of these rules is expected to create a robust battery recycling industry in India, providing a steady supply of recycled materials for battery production and reducing the reliance on imported raw materials.

While these circular economy policies establish the regulatory framework, their success depends on the available infrastructure for vehicle assessment and end-of-life processing.

Current state of vehicle testing and scrapping facilities

India's vehicle testing and scrapping network is still in its infancy, with fewer than 300 facilities currently operational nationwide, less than half of the over 600 that are required to adequately meet the existing demand.[28] The Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021, mandate the establishment of automated fitness centres (ATSs) to test and certify vehicles as fit for use. Vehicles declared unfit are required to be scrapped at registered vehicle scrapping facilities (RVSFs). Currently, India has over 100 operational ATS facilities and approximately 100 RVSFs, with the network continuing to expand rapidly.

The establishment of these facilities is crucial to implement the vehicle scrappage policy effectively. ATSs are equipped with advanced testing equipment to assess the fitness of vehicles, ensuring that only roadworthy vehicles are allowed to operate. RVSFs, on the other hand, are designed to dismantle and recycle end-of-life vehicles in an environmentally friendly manner. The expansion of the vehicle testing and scrapping facility network is expected to create a robust ecosystem for vehicle recycling, helping to cut vehicular emissions and implement sustainable mobility.

Major automotive OEMs in India have also made notable progress in promoting vehicle scrapping initiatives. These efforts are crucial for creating a formal e-waste management sector and promoting eco-friendly product design.

India's journey toward sustainable mobiity is an ongoing pursuit of an entire ecosystem that supports achieving sustainability goals. Concerted efforts, as described in the next chapter, could accelerate this progress.

[27] Battery Waste Management Rules, Central Pollution Control Board, accessed on September 4, 2025.
[28] State wise available RVSF details, Ministry of Road Transport & Highways, accessed on September 4, 2025.

03

How India could accelerate sustainable mobility

India has embarked on a bold mission to transform its mobility ecosystem into a resilient, sustainable, and future-ready model. To gain traction and achieve its ambitious sustainable mobility goals, India could focus on four key imperatives: strengthening the local supply chain for critical raw materials, expanding the infrastructure for alternative powertrain adoption, promoting circular business building, and piloting shared mobility interventions in key cities. Each of these imperatives is crucial for creating a robust and resilient ecosystem that supports sustainable mobility.

Strengthen the local supply chain for critical raw materials

India's sustainable mobility journey begins with strengthening its local supply chain for critical raw materials. This would involve several measures:

1. **Invest in advanced research and development for newer battery technologies:** India can prioritize R&D investments in battery technologies that offer higher localization potential. This includes exploring diverse chemistries such as Lithium Iron Phosphate (LFP) and Sodium-ion (Na-ion) batteries. LFP batteries are favored for their lower costs, safety, and longer cycle life, while Na-ion batteries, which leverage India's abundant sodium sources, could become commercially viable by the 2030s. Major EV OEMs have already begun selling LFP-based EVs, and battery suppliers are investing in technology to expand the market for new chemistries.

   The development of these battery technologies is not just about meeting current demand but also about future-proofing India's mobility sector. By investing in these technologies, India can aim to source more locally manufactured or assembled batteries, reducing its exposure to global supply-chain volatilities. The establishment of local manufacturing units for these batteries can also create numerous job opportunities, thereby boosting the local economy. The government could provide subsidies and incentives for companies that invest in R&D and manufacturing of these advanced battery technologies. Collaborations between academic institutions and industry players can accelerate the pace of innovation and commercialization of these technologies.

2. **Mitigate geopolitical risks in sourcing raw materials:** To ensure a stable supply of critical raw materials like rare earths, India could adopt redundancy measures. This includes forming strategic partnerships and free trade agreements (FTAs) with countries that can provide a steady supply of essential materials. Additionally, India could develop in-house capabilities to reduce reliance on imported materials, such as creating magnet-less motors that do not require rare earth metals. Recent measures by OEMs for procuring rare earth metals offer examples of resilient operating modes, such as diversified component sourcing and long-term contracts, R&D to minimize reliance on critical raw materials when necessary. The geopolitical landscape is dynamic, and reliance on a few countries for critical raw materials can pose significant risks. By diversifying its sources and building strategic reserves, India can safeguard its mobility sector from potential supply chain disruptions. Investing in the recycling of rare earth materials can provide a sustainable and environmentally friendly alternative to mining. The government

could consider the possibility of establishing joint ventures with countries rich in these resources, ensuring a more secure and consistent supply. Public–private partnerships can be instrumental in developing technologies to reduce the dependence on these critical materials, further strengthening India's position in the global mobility market.

3. **Leapfrog in hydrogen powertrain adoption:** By localizing electrolyzer manufacturing, India can improve the accessibility of green hydrogen. The country has the potential to become a globally competitive electrolyzer manufacturing hub, leveraging its cost advantages in electricity and labor compared to the European Union and the United States. This strategic move can significantly lower manufacturing costs and enhance the adoption of hydrogen powertrains. Hydrogen is often touted as the fuel of the future, and for good reason. It offers a clean and efficient alternative to fossil fuels, with water being the only byproduct. India can reduce the cost of hydrogen production by investing in the local manufacturing of electrolyzers, making it more accessible for various applications, including transportation. Establishing hydrogen refueling stations across the country can further promote the adoption of hydrogen-powered vehicles. Collaborations with international players can bring in the necessary expertise and technology, accelerating the development of a robust hydrogen ecosystem in India.

Expand the infrastructure for alternative powertrain adoption

To support the widespread adoption of alternative powertrains, India can draw lessons from the expansion of its CNG network, and focus on key demand hubs and address pain points like interoperability. A fully interoperable EV charging network can alleviate range anxiety for customers and utilization anxiety for charge point operators (CPOs). This involves developing a clear vision and roadmap for the EV charging network, prioritizing locations, and ensuring long-term economic viability and sufficient network coverage. The lack of a Unified Energy Interface (UEI) limits EV charger discoverability, but interoperability can resolve this challenge by allowing end customers to use any interface to discover charging points.

The expansion of the EV charging network is crucial for the mass adoption of electric vehicles. By focusing on key demand hubs such as metropolitan cities and major highways, India can ensure that EV users have access to charging facilities wherever they go. Collaboration between the government and private players to set up charging stations, supported by incentives such as subsidized land rates and tax breaks, would be advantageous in accelerating infrastructure development. Integrating renewable energy sources such as solar and wind, with these charging stations can further enhance their sustainability. Public–private partnerships can play an important role in this expansion, with private companies providing the necessary investment and expertise, while the government offers regulatory support and incentives. The development of fast-charging technologies can reduce the time taken to charge an EV, improving user convenience.

Promote circularity

Circular business practices are essential for sustainable mobility. India can set up material circularity lighthouses to assess the top-line implications and build a business case for embedding circular practices:

1. **Develop a circular lighthouse vehicle:** Automotive OEMs can design a circular lighthouse vehicle optimized for carbon, cost, and circularity (Exhibit 7). This involves using bio-based premium materials, upgradable batteries, and EV motors without rare earth materials. The goal is to achieve zero waste and zero emissions throughout the vehicle's lifecycle. Illustrative examples of circular building blocks include ultralightweight and durable bodies with carbon fiber from connectivity control units (CCUs). The concept of a circular lighthouse car represents a paradigm shift in automotive manufacturing. By focusing on sustainability from

Exhibit 7

Circular lighthouse: OEMs need a repository of circular building blocks like materials and technologies to build a circular vehicle

Illustrative examples of circular building blocks

Xxx Potential targets for circular vehicle project

Triple mission

Triple mission: all parts optimized for carbon, cost and circularity duringMDS

–20% cost reduction, CO2 and virgin material

One screen for all

Consolidate interaction points for ease of refurbishment

1 standardized driver interface

Closed loop

Closed-loop recycling from post-consumer automotive parts

80%+ recycled material content

Design for assembly

Detachable joints and connections through minimal gluing and welding and accessibility of screws

–90% time to disassemble

Carbon fiber from CCUs

Ultralightweight& durable body with carbon fiber from CCUs

0 CO2 emission from vehicle body

Mono materials

Mono-material car panels with separated inner/outer surfaces and minimal use of paint/finish for full recyclability

100% recyclability and –50% CO2 emissions on exterior

Bio-based materials

Bio-based premium materials and parts(e.g. Mycelium-based leather)

–80% reduction in fossil-based material use

No animal-based materials

Substance database

Minimal set of standard materials(PET, PP, HDPE, Wood, Steel, PLA)enabled by "Substance Database"

<500 materials used in car

Plastics made from waste

Carbon-negative parts from thermoplastics made from waste

No net emissions from plastic parts

Minimal stamping

Parts designed for minimal waste from stamping

0 waste from stamping

Upgrade as a service

Upgradable batteries for best performance

90%+ performance guarantee

No rare earths

EV motor without rare earth materials

0 reliance on rare earth materials

Removable seat textiles

Removable textiles for easy cleaning and change

Maximum durability of seating

Circular part platform

Fully circular maintenance with availability of refurbished parts

–50% reduction in virgin material need for spare parts

Zero waste	**Zero emission**	**80%+**	**100%**	**15%**
In production and end-of-life	Along product lifecycle (Scope 1-3)	Recycled material content used	Recyclable end-of-life	Increased mileage due to lightweight design and efficiency

Source: McKinsey Sustainability Insights

the design stage, manufacturers can create vehicles that are not only environment friendly but also cost-effective in the long run. The use of bio-based materials can reduce the vehicle's carbon footprint, while upgradable batteries can reduce the need for frequent replacements. The development of EV motors without rare earth materials can minimize the dependence on critical raw materials and lower production costs. Collaborations with international players can bring in the necessary expertise and technology, accelerating the development of circular vehicles.

2. **Scale up ELV collection and sorting ecosystem:** By extending the useful lifecycle of vehicles and components through take-back and second-life programs, OEMs can generate positive business impacts and reduce carbon and virgin material usage. This approach also involves building an end-of-life vehicle (ELV) collection and sorting ecosystem to enhance recycling and business model innovation. The current end-of-life (EOL) value chain is low-tech and fragmented, primed for a step-change in recycling and business model innovation. A robust ELV collection and sorting ecosystem can ensure these vehicles are properly recycled, reducing environmental impact. Collaborations with international players can bring in the necessary expertise and technology to enable this.

Develop tailored interventions to expand shared mobility options in key cities

Shared mobility interventions can considerably reduce congestion and emissions in urban areas. India could tailor such interventions for select cities that already have some mobility targets:

1. **Identify and develop tailored solutions:** Certain Indian cities have set mobility targets, including increasing the modal share of public transport and reducing greenhouse gas (GHG) emissions. Tailored solutions for these cities include enhancing public transportation infrastructure, fostering non-motorized transport options, and incentivizing a modal shift from private vehicles to public transit. For instance, Delhi's latest EV policy aims to alleviate the city's air quality problems by setting a target for 27 percent of all vehicle registrations to be electric by 2027.[29] Shared mobility solutions, including ride-sharing, carpooling, and bike-sharing, can also help alleviate congestion and emissions. Setting up dedicated lanes for shared mobility vehicles can improve their efficiency and attractiveness. Collaborations with private players can bring in the necessary investment and expertise, accelerating the development of shared mobility solutions.

2. **Leverage existing climate action plans:** Climate action plans provide a roadmap for cities to achieve their sustainability goals. Cities can align shared mobility initiatives with these plans, cities can ensure a coordinated and comprehensive approach to reducing emissions and promoting sustainable transportation. For instance, Bengaluru's plan focuses on transit-oriented urban planning and aims to achieve a combined public transport and non-motorized transport modal share of 75 percent by 2030 and 85 percent by 2050.[30] Mumbai's Climate Action Plan[31] also outlines an ambitious vision to achieve net-zero GHG emissions, with an emphasis on sustainable mobility. Setting up pilot projects in chosen cities can provide valuable insights and best practices that can be scaled up to other cities. Collaborations with international players can bring in the necessary expertise and technology, stepping up the development of shared mobility solutions.

[29] Amulya Raj Srinet, "Delhi EV policy 2.0 aims for 95 percent EV adoption by 2027," NDTV, March 13, 2025.
[30] Carbon Credits HQ, "Summary of Bengaluru Climate Action and Resilience Plan," blog entry by Aashman Trivedi, August 21, 2024.
[31] "Mumbai's First Climate Action Plan (MCAP) Released." The Times of India, March 13, 2022.

The government could also facilitate the acceleration of sustainable mobility, supporting the described initiatives. It could offer subsidies and tax breaks for hydrogen fuel cell adoption, mandate ethanol-blended fuels for public fleets, and incentivize research, circular manufacturing, remanufacturing, and recycling technologies. Support for shared mobility operators, including integrated public transport, and dedicated project funding can further strengthen the ecosystem for green and innovative transportation solutions.

Another way to ensure consumer acceptance and adoption of alternative powertrains and sustainable mobility adoption are targeted public awareness campaigns. Public messaging can highlight the unique benefits of cleaner fuels like flex fuels, electric vehicles and charging options, circular vehicles, and shared mobility services to ensure that people make more sustainable choices across the transportation landscape.

The imperatives described in this chapter could be crucial for India. Effectively implementing these could help to shape a robust ecosystem that supports sustainable mobility, ensuring long-term benefits for the country.

Conclusion

India's roadmap for achieving sustainable mobility involves collaboration between various stakeholders, including the government, private sector, and the public. The transition to alternative powertrains, such as electric and bio-fuels and flex fuel vehicles, is crucial for reducing the country's carbon footprint and achieving energy independence. The government's proactive policies, such as subsidies for electric vehicles and investments in charging and CNG refuelling infrastructure, have already laid a strong foundation for this transition.

Additionally, the focus on localizing the production of critical components, such as batteries and electrolyzers, could not only reduce dependency on imports but also create job opportunities and boost the local economy. The adoption of shared mobility solutions and the promotion of circular business practices further complement these efforts by reducing congestion, lowering emissions, and promoting resource efficiency.

However, the journey towards sustainable mobility is not without its challenges. The success of these initiatives hinges on the effective implementation of policies, the development of robust infrastructure, and the active participation of all stakeholders.

Public awareness campaigns are crucial in driving consumer acceptance and adoption of new technologies. In addition, international collaborations can bring in the necessary expertise and technology to accelerate the development of a sustainable mobility ecosystem. By addressing these challenges and leveraging opportunities, India can pave the way for a greener and hyper-efficient transportation system that serves both its growing population and advances the world's collective fight against climate change.

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