# Investor Perspectives on Accelerating Growth in the Indian EV Ecosystem

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## International Institute for Sustainable Development

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1. A roundtable held under the Chatham House rule on Understanding Investment Opportunities, Barriers, and Priorities for a Globally Competitive EV Manufacturing Sector in India – organized on 15 February 2022 by ClimateWorks Foundation, the Center on Global Energy Policy, ICRIER, IISD, Invest India, Shakti Sustainable Energy Foundation, and WBCSD.
2. A day-long event on Understanding Investment, Trade, and Battery Waste Management Linkages for a Globally Competitive Electric Vehicles Manufacturing Sector – organized on 29 April 2022 by ICRIER, ClimateWorks Foundation, and IISD.

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# Executive Summary

Addressing global warming depends in large part on the decarbonization of transport sectors around the globe. Perhaps no individual country—with the possible exception of China—can have a greater impact in this regard than India. With its large and growing economy and population, India is likely to add hundreds of millions of vehicles to its roads in the next few decades, making it the fastest-growing car market in the world. This means increased demand for fossil fuels and, in turn, increased greenhouse gas emissions. If India wants to meet the net-zero climate goals that it set last year at the 26th Conference of the Parties in Glasgow, it will need to find ways to accelerate its transition from internal combustion engine vehicles to electric vehicles (EVs).

India has already pledged that by 2030 30 percent of all new vehicle sales in the country will be EVs, a policy goal that has many strategic advantages beyond helping India reduce its carbon emissions, including energy security. In support of this pledge, it has introduced important initiatives at the national and state levels, not least its flagship EV scheme, Faster Adoption and Manufacturing of Electric Vehicles, which provides purchase subsidies to consumers. For India to keep pace with its ambitions, however, it will need substantially more foreign direct investment. Presently, there is a major gap between the investment levels in EVs and batteries required to remain aligned with net-zero scenarios and existing investment levels. But there is also strong optimism, including among investors, around India's EVs sector and its growth potential.

This report is a joint effort between Columbia University's Center on Global Energy Policy, the International Institute for Sustainable Development, the Indian Council for Research on International Economic Relations, and Invest India. It is intended to take stock of India's current EVs ecosystem and where the sector may be heading in the future, with a focus on drivers of and barriers to investment. The research for this study mainly involved in-depth consultations with experts, policymakers, investors, and companies, as well as results from an online survey with 59 EV experts and companies. The report presents the main takeaways of this research, which can be summarized as follows:

- India is successfully incentivizing consumer demand for electrified two-wheel and three-wheel vehicles and is beginning to scale up demand for electrified four-wheel vehicles and buses, too.
- India remains a minor player in battery manufacturing, which is still dominated by China, but it has initiated policy schemes to incentivize battery manufacturing in the country. Consulted investors and companies see major growth potential for India in this realm, which they believe will help it to expand domestic battery production and EV adoption dramatically.
- For India to achieve the scale of EV growth it desires, however, it will need to address financing challenges for consumers and the country's insufficient charging infrastructure. Although the government has formulated policy solutions on both fronts, investors and companies consulted for this report identified space for improvement and expansion. Other potential obstacles to this growth include supply

chain shortages, lack of complementarity between state and federal policies, and skill gaps in the labor force.

- The country could also embrace battery swapping, which experts believe can help to expand EV demand and adoption and which the Indian government has already begun to support through policy initiatives.

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# 1.0 Introduction

The decarbonization of the transport sector is vital to preventing global warming of more than 1.5°C above preindustrial levels, a central component of net-zero ambitions worldwide, and the most important carbon emission reduction measure aside from greening the power sector (Moerenhout 2021a; 2021b). With 24 percent of global greenhouse gas emissions coming from the transport sector and more than 40 percent of those emissions caused by passenger road vehicles, the electrification of passenger transport has become a central focus of global efforts to decarbonize the sector (IEA 2022). Indicatively, at the 26th Conference of the Parties (COP26) summit held in Glasgow in 2021, 38 national governments, 47 city and regional governments, 11 automotive manufacturers, 28 fleet owners, and several investors and financial institutions committed to a pledge that by 2035 all new sales of cars and vans sold in leading markets will be zero-emission vehicles (ZEVs; COP26 2021).

Amid the global transition to ZEVs, the case of India is particularly important. Given its rapidly growing economy and its population of almost 1.4 billion people and counting, the country is expected to add an additional 300 million vehicles to its roads by 2040—the largest car market growth of any country in the world, leading to a four million barrel per day increase in its oil demand (IEA 2021b). In response, the Indian government has pledged that by 2030 30 percent of all new vehicle sales in India will be electric. This attempt to make the uptake of electric vehicles (EVs) a strategic objective aligns with India's goal of reducing carbon intensity per unit of gross domestic product (GDP) by 45 percent by 2030 (PTI 2021). It can also act as a green industrial policy to support a postpandemic economic recovery; reduce oil imports and strengthen energy security; and lessen air pollution and mitigate climate change.

For India to follow through on its pledge, the Indian EV market will need a considerable inflow of foreign direct investment (FDI). Although investment in EVs and batteries is rapidly scaling up around the world, much more is needed. It is estimated that $2.5 trillion in global cumulative public and private investments will be required to shift to 100 percent EVs, which is about fivefold the current investment levels (Assis 2021). A recent study has estimated that original equipment manufacturers (OEMs), also known as automakers, are planning to spend about $500 billion on EVs and battery production by 2030 (Lienert and Bellon 2021), a significant increase from prepandemic levels of $300 billion by the same year. The main destination for this investment is China, which receives almost half, followed by several EU countries, most notably Germany (Lienert and Bellon 2019).

According to the Council on Energy, Environment, and Water, India's EVs and charging infrastructure investment needs will amount to $180 billion in the 2020s alone (Singh, Chawla, and Jain 2020). Meanwhile, total EV investment announcements for 2021 in India reached only $6.5 billion (NITI Aayog, RMI, and RMI India 2022a), leaving a significant gap between required and actual investment. Nevertheless, the National Institution for Transforming India (NITI Aayog), the Indian government's premier policy think tank, believes that cumulative investment in India's EV transition between 2020 and 2030 could be as large as $266 billion, reflecting growing optimism for the sector (NITI Aayog, RMI, and RMI India 2022a).

The purpose of this report is to analyze India's present EV ecosystem with a focus on drivers of and barriers to investment. Based on in-depth consultations with experts, policymakers, investors, and companies, as well as results from an online survey with 59 EV experts and companies, it presents nine takeaways highlighting (1) the state of play of India's EV market and policies, (2) the main challenges to further improving its EV ecosystem, (3) government and investor initiatives to alleviate those challenges, and (4) additional challenges to and solutions for accelerating investment.

# 2.0 Takeaway 1

## India's recent policies have been successful in incentivizing consumer demand for electric two-wheelers (2W) and three-wheelers (3W), with electric four-wheelers (4W) and buses also scaling up.

India's flagship EV scheme, Faster Adoption and Manufacturing of Electric Vehicles (FAME), has been critical to incentivizing EV demand in the country. The government's commitment to electrifying its transport sector is particularly clear in its move from the first phase of the program (2015–2019), which cost $128 million, to the second phase (2019–2024), which increased government subsidies tenfold to $1.35 billion. Whereas phase I aimed at supporting 280,000 EVs, phase II scaled up vehicle sales by 1 million 2Ws, 500,000 3Ws, 55,000 passenger cars, and 7,090 buses.

In support of this ambitious goal, the FAME program's demand-side incentives effectively lower the upfront purchasing price of EVs through a government subsidy to OEMs. FAME II started with an EV purchase subsidy of $134 (10,000 rupees [Rs]) per kilowatt hour (kWh). In 2021, the Indian government increased that subsidy by 50 percent for 2Ws to $201 (Rs 15,000) per kWh, bringing the ratio of subsidy to total vehicle cost from a maximum of 20 percent to a maximum of 40 percent (Government of India Department of Heavy Industry 2019, 2021c). This measure, in combination with state-level incentives in Delhi, Maharashtra, Gujarat, and elsewhere, has sharply reduced the up-front cost of EVs, especially in the 2W and 3W segments, accelerating the electrification of last-mile mobility.

Two other policies have likewise incentivized EV demand. In 2019, the Indian government reduced the goods and services tax (GST)—an indirect tax levied on the supply of goods and services that came into effect in 2017 and replaced many indirect taxes such as excise duties and value-added tax—on EVs and chargers from 12 percent to 5 percent (Reuters Staff 2019), while internal combustion engine (ICE) vehicles maintain a GST rate of 28–43 percent. Additionally, it offered tax deductions for first-time buyers of EVs to the level of $2,000 on loans concluded between 2019 and 2023. Importantly, this scheme includes 2Ws (Government of India Income Tax Department 2021), which make up about 75 percent of the total vehicle fleet in India (Statista 2022).

The impact of these policies has been reflected in EV sales. Whereas in FY2020–21, India's EV penetration rate (i.e., EV sales as a percentage of total sales) was less than 1 percent, by the close of FY2021–22, it was up to 2.5 percent (Invest India 2022). Many consulted stakeholders believe that the FAME II scheme amendment played a major role in this shift, though this is difficult to verify without user surveys. From the OEMs' side, major companies believe their marketing efforts have helped to increase public awareness of EVs. The success of demand-side incentives has been especially significant in the 2W segment, where sales more than quintupled from FY2020–21 to FY2021–22. Other segments such as 3Ws, buses, and PVs tripled in size in that same period. Certain metro cities, such as New Delhi, have witnessed EV penetration of over 9 percent in new vehicle sales compared to the national average of 2.5 percent (ibid.). The Indian government is expecting to achieve a 16 percent EV

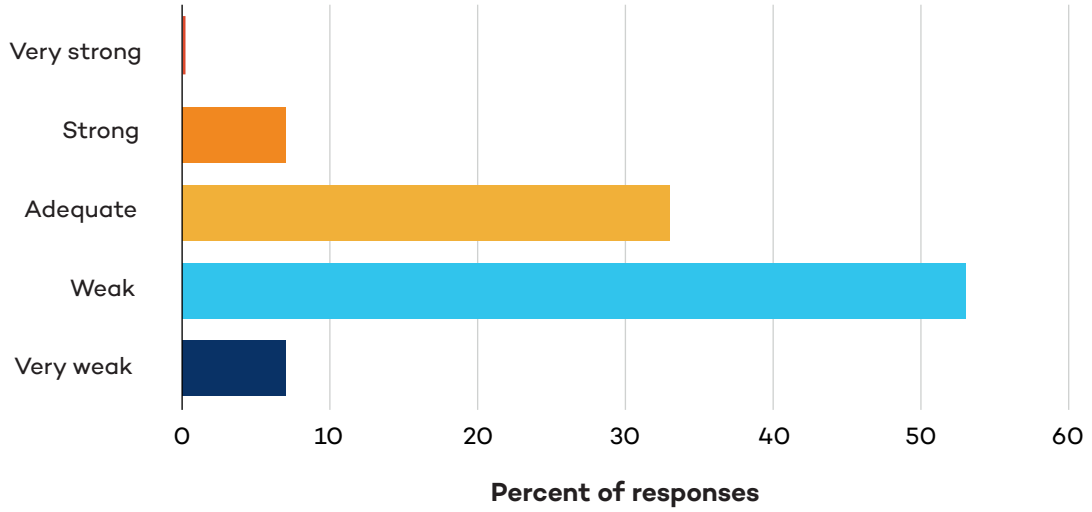
penetration rate in the 2W segment and a 20 percent EV share in the 3W segment (in addition to a 13 percent EV share of transport buses) by 2025. By comparison, the government expects 4W passenger cars to electrify at a slower pace, reaching only a 5 percent penetration rate by the same year (ibid.).

# 3.0 Takeaway 2

## Financing challenges remain, but solutions are being developed.

The FAME scheme has been instrumental in improving the affordability of EVs. If India's goal is to exponentially increase EV adoption, however, it will need further policy innovations that address financing challenges for consumers. For example, electric 2Ws currently incur higher interest rates and down payments as well as shorter loan periods than equivalent ICE vehicles. To date, reputed OEMs have offered relatively few electric 2Ws and 3Ws, making it more difficult for financiers to understand the lifespan and depreciation of these vehicles. The limited availability of dedicated financing options keeps up-front costs high for consumers, despite an already low total lifetime cost of ownership (TCO) in certain EV segments compared with ICE vehicles. Reflecting this point, most of the investors consulted for this report saw current financing models to be between weak and adequate (see Figure 1) and ranked the high purchasing costs of EVs as the foremost consumer demand barrier to upscaling investment in electric mobility in India (see Figure 2).

**Figure 1.** What is your evaluation of current financing models available for EV users in India?

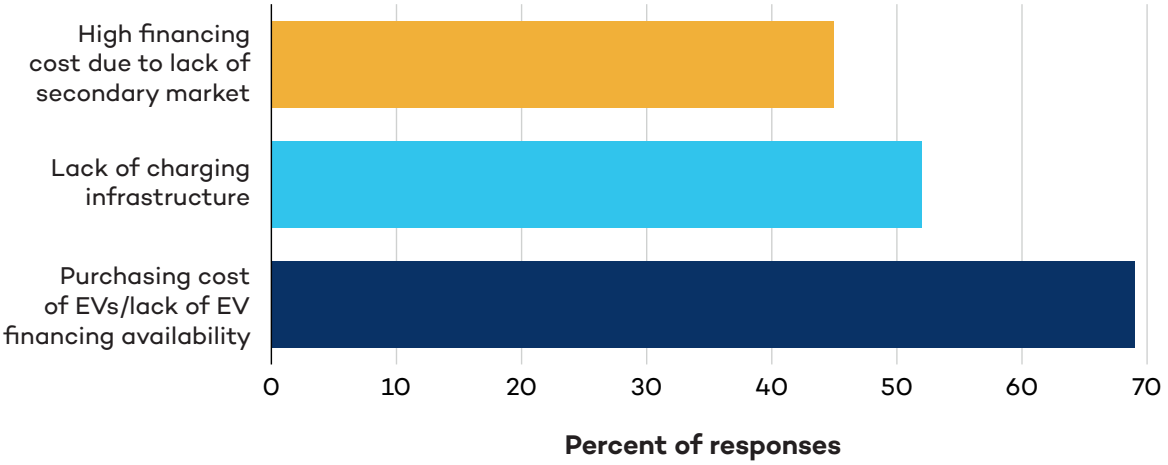



Source: Authors' survey.

Aware of the purchasing cost challenge of EVs, the Indian government recently proposed two initiatives intended to improve financing for the sector. The first, set up by the Indian government think tank NITI Aayog and the World Bank, is a $300 million, first-loss risk-sharing instrument that protects banks from EV-related loan defaults and effectively lowers the interest rate for consumer loans from 20–25 percent to 10–12 percent. It is estimated that under the program the total financing of the State Bank of India—which will act as a program manager—could reach $1.5 billion (Bhardwaj 2021; Philip and Shukla 2021).

The second, recommended by NITI Aayog and the Rocky Mountain Institute (RMI), involves including EVs in the Reserve Bank of India's priority sector lending (PSL), a policy that obliges banks to allocate a certain percentage of their lending to priority sectors. This step would bolster investor confidence in two ways. First, like the World Bank facility, it would increase the availability of capital for EV purchasing, including for segments that are economically rational but where consumers struggle with credit. Second, it would send a clear signal to investors that the government is committed to EVs in the long term (NITI Aayog, RMI, and RMI India 2022a). At the time of writing, this measure has not yet been formally approved.

**Figure 2.** Select a maximum of three consumer demand barriers to upscaling investment in electric mobility in India.




Note: Survey particiants selected up to 3 barriers from a list of 11.

Source: Authors' survey.

Addressing the financing of EVs at the federal and state levels can yield significant results across EV segments. One survey found that 90 percent of consumers would consider paying a premium for an EV if the supportive infrastructure was available, including for electric 4Ws (Bureau 2021). This consumer interest could be further bolstered by more transparent data on vehicle performance and the expansion of industry-led buyback programs.

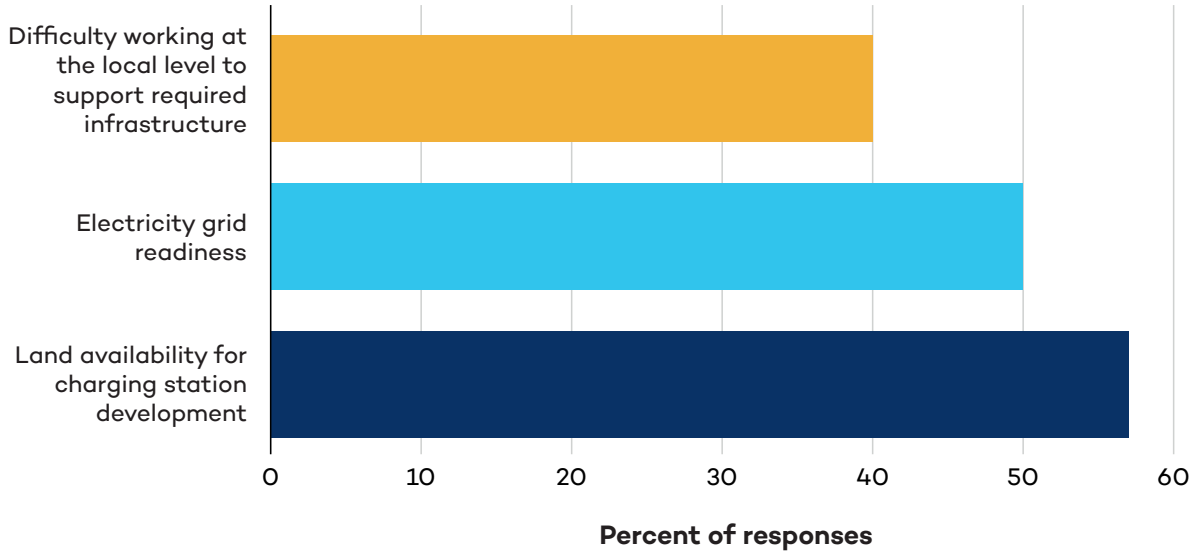
# 4.0 Takeaway 3

## The availability of sufficient charging infrastructure is of high concern to all stakeholders despite government subsidies.

Infrastructure bottlenecks often stall technology adoption, and the case of EVs is no different. Today, charging infrastructure availability is considered as much of an EV-adoption bottleneck as up-front costs (Foster et al. 2021). The global number of chargers is expected to increase from about 10 million in 2020 to 120 million in 2030, though 210 million are needed to stay on track with the goal of limiting global warming to less than 1.5°C above preindustrial levels (IEA 2021a).

Reaching that volume of chargers would require governments around the world to offer public subsidies for charging infrastructure to the level of billions of dollars. Some countries have already adopted this measure. As part of green Keynesian policies since the start of the COVID-19 pandemic, the United States has committed $7.5 billion, Germany $2.9 billion, China $1.5 billion, and Italy $850 million (Energy Policy Tracker 2022). However, many more countries, especially those with large auto markets, will need to follow suit.

**Figure 3.** Select a maximum of three infrastructure demand barriers to upscaling investment in electric mobility in India



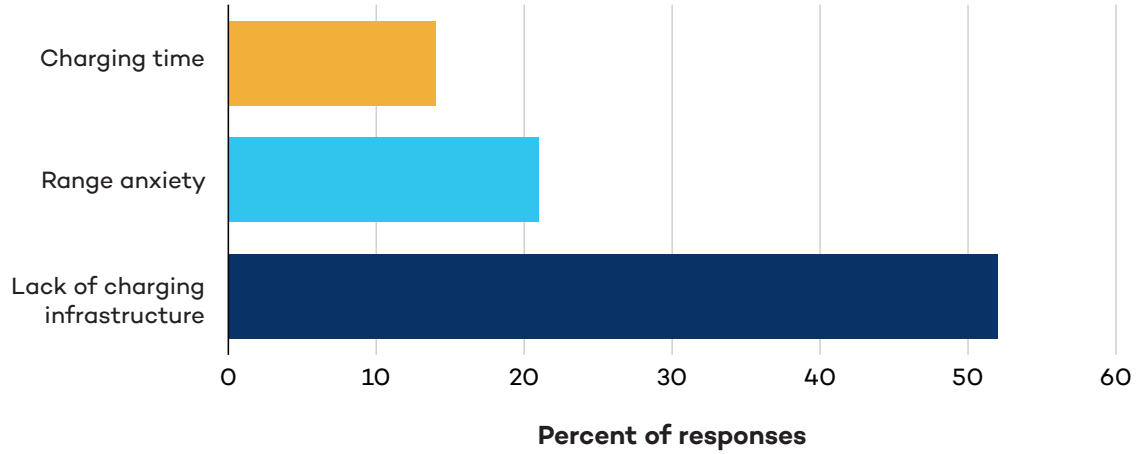

Note: Survey particiants selected up to 3 barriers from a list of 9.
Source: Authors' survey.

Currently, India has a total of only about 1,800 public charging stations (Gadkari 2022). 2Ws will require 634 chargers by 2025 and 3,866 chargers by 2030, about 10 percent of which are expected to be public; 3Ws will require 2,557 chargers by 2025 and 9,826 chargers by 2030, about 20 percent of which are expected to be public; passenger 4Ws will require 32 chargers by 2025 and 306 chargers by 2030, about 10 percent of which are expected to be public; and commercial 4Ws will require 262 chargers by 2025 and 2,303 chargers by 2030, about

25 percent of which are expected to be public. In total, this additional charging capacity will require 0.45 GWh of extra power by 2025 and 2.4 GWh by 2030 (NITI Aayog et al. 2021).

India's current level of public investment in charging infrastructure also lags behind major EV ecosystems around the world. Under FAME II, India committed Rs 10 billion (equivalent to $134 million) to support the progressive installation of EV charging infrastructure (Government of India Department of Heavy Industry 2019). This amount is in line with the commitment level of Canada, which pledged $112 million for charging infrastructure (Energy Policy Tracker 2022). Like in other countries, achieving deep EV penetration in India will require additional subsidies for and investment in charging in the short term. Indicatively, consulted experts and investors viewed the second-largest EV consumer demand barrier to be a lack of charging infrastructure, behind only the high purchasing cost of EVs and much more important than charging time or range anxiety (see Figure 3). Meanwhile, they identified land availability for charging station development and electricity grid readiness as the two largest charging infrastructure barriers (see Figure 4).

**Figure 4.** Select a maximum of three infrastructure demand barriers to upscaling investment in electric mobility in India




Note: Survey particiants selected up to 3 barriers from a list of 11.
Source: Authors' survey.

Despite concerns over charging availability, the installation of EV charging stations is accelerating in India. Under FAME I, the Indian government sanctioned 520 public charging stations; under FAME II, it has sanctioned 2,900 stations, with another 1,600 in development or being planned. The Indian government also reduced GSTs levied on EV chargers from 18 percent to 5 percent (NITI Aayog, RMI, and RMI India 2022b). In an attempt to facilitate the further development of public and private EV charging infrastructure, the Ministry of Power issued consolidated guidelines and standards for it in January 2022.

Several plans for adding charging infrastructure in India are underway. If implemented effectively and supported with public and private investment, they could help incentivize EV adoption:

- Nine megacities in India more than doubled the number of public charging stations between October 2021 and January 2022. These stations were installed following the Indian government's decision to prioritize charging infrastructure in cities with a population of over four million people. The installation effort fits within the goal of India's Department of Heavy Industry to double the number of public charging stations in the country (Gadkari 2022).
- The National Highway Authority of India is aiming to set up EV charging stations every 40 to 60 kilometers along India's national highways to further boost 4W EV penetration in the country (Chauhan 2021). India's largest EV charging station, with a capacity of 100 charging points for 4Ws, was opened in early 2022 along the Delhi-Jaipur National Highway in Gurugram. India's previously largest EV charging station, with 16 AC and 4 DC charging ports for EVs, was situated in Navi Mumbai. In general, the official government target is to have one public charging station every 25 kilometers and one fast charging station every 100 kilometers along major highways (Government of India Ministry of Power 2022b).
- State-owned oil marketing companies in India plan to install 22,000 EV chargers in prominent cities and on major highways over the next few years, indicating a potentially rapid growth in charging infrastructure in the near future (Government of India Ministry of Power 2022a).
- Many startups in India's online delivery space (grocery, food, and e-commerce), such as Zomato and Flipkart, have started transitioning their vehicle fleets to EVs. Some of these players have already committed to the Climate Group's EV100 initiative. The players in this group are setting up their own captive charging stations in large cities.
- Mobility services players, such as BluSmart, in collaboration with JioBP, are setting up mega charging stations in the heart of large cities for their own captive needs.
- The Indian government has attempted to facilitate charging by offering EV bus purchasers one slow charger per bus and one fast charger for every 10 buses that fall under the scheme (Government of India Department of Heavy Industry 2019).

Consulted investors identified four policy concerns that need to be addressed to accelerate charging infrastructure deployment:

- First, charging subsidies under FAME II are limited to high-capacity chargers primarily used for 4W passenger cars, which is at odds with the overall scheme supporting a much heavier market penetration of 2Ws (1 million units) and 3Ws (500,000 units). Meanwhile, the subsidy program effectively puts the burden of expanding 2W and 3W charging infrastructure on charging point operators by requiring the installation of 2W and 3W chargers for eligibility. Consulted investors wanted to see greater government investment in dedicated 2W and 3W charging infrastructure.

- Second, in previous guidelines, the government indicated that state governments had the right to cap the charging fee of any charging point operator that benefited from a subsidy. In updated guidelines, they extended this rule to any operator that received an electricity connection from the distribution company, which encompasses nearly all operators in India. The new guidelines forced operators to assess risk and calculate return on investment, both of which are inevitably linked to charging fees. While consulted investors understand that distribution companies must charge for electricity connections and the government must charge operators for certain provisions such as land, they reported concerns regarding the uncertainty that comes with the potential capping of charging fees.
- Third, it remains unclear who is supposed to pay for grid accreditation—often, charging point operators do—which can cost as much as the equipment. Consulted investors identified the need for clear market rules around setting up charging infrastructure.
- Fourth, like elsewhere in the world, India's charging infrastructure land needs are concentrated in premium locations, making the availability and cost of land a paramount concern, including among consulted investors. The Indian government has already taken critical steps to address this concern, such as allowing state-owned entities to offer land to private charging point operators through a bidding process that values state-owned land at a minimum of one rupee per kWh (and exactly one rupee per kWh for state-owned charging point operators; *Economic Times 2022*). By using this revenue-sharing agreement, local governmental bodies can accelerate the installation of charging stations.

In addition to these four concerns, some of which federal, state, and local governments are already working to address, investors indicated a broader concern about the financial viability of Indian distribution companies and thus their capacity to invest the capital needed for charging infrastructure.

Across the world, electricity supply will need to be upgraded to accommodate EV charging (Moerenhout 2021a). Distribution companies can facilitate EV adoption by embracing forward-looking business and management approaches, having single points of contact for charging point developers, communicating clearly about hosting capacity on distribution networks, making siting processes easier and faster, encouraging demand-side management, so charging happens at the time of day when power demand is low, and linking up chargers with renewable energy (Arora and Korsh 2021). Consulted investors and government officials agree that addressing this potential technology adoption bottleneck would further enhance trust in India's EV ecosystem.

Much progress has been made to reduce the time it takes to obtain charging connectivity from distribution companies. Whereas this process used to take up to six months, India's Ministry of Power recently published revised guidelines that encourage utilities to complete it within 15 days (though these have not yet been implemented in many states). However, improving charging connection times will require investment on the electricity supply side. Whereas in 2018 EV batteries demanded 2.9 GWh, by 2030 they are expected to demand 158 GWh, with over 50 percent of that coming from 2Ws (Invest India 2022). Once again, this highlights the

importance of distribution companies to EVs, which can be a challenge given the financial stress these companies are under, with total losses amounting to almost $23 billion in 2021 (Regy et al. 2021). The Indian government is currently suggesting that distribution companies use the recently launched Rooftop Solar Scheme, which aims to install a cumulative capacity of 40 GW from rooftop solar projects by 2022, to provide less expensive upstream infrastructure to charging point operators.

# 5.0 Takeaway 4

## Battery swapping can alleviate considerable demand-side concerns.

The up-front costs of EVs are largely determined by the price of the battery. This makes battery swapping, which allows consumers to purchase an EV at a lower cost without the battery and then use swapping stations to load full batteries and unload empty ones, a potentially attractive incentive option—one that can also help to address other constraints such as insufficient charging infrastructure and lack of dedicated parking space in urban settings. Although users would need to pay for battery swapping services, these costs would be incurred across the lifespan of the vehicle. Currently, discussions of battery swapping in India are focused on 2Ws and 3Ws.

Battery swapping in India could resolve additional obstacles to EV adoption, all linked to the fact that the initial traction for EV adoption is in major cities, including state capitals: the lack of parking space in urban centers due to land availability issues; the use by urban high-rise buildings of diesel-based generators, which are costly and polluting, to satisfy part of their electricity demand; and the need to add EV chargers to urban residential buildings, which could increase load requirements on the grid, especially during peak demand hours. These factors, in combination with India being the largest 2W market in the world, could make battery swapping a viable solution in India's large cities.

Many challenges still need to be overcome, however, for battery swapping to flourish. Currently, major vehicle manufacturers do not share their battery technology information with each other and are not required to do so by intellectual property regulations. This means that different battery designs may not work for different EVs, limiting the potential economies of scale of the battery swapping model. Moreover, taxation of swappable batteries in India is significantly higher (18 percent) than that of fixed batteries (5 percent; Charan 2022), making them cost prohibitive.

Experts believe that swapping could contribute to 30 to 40 percent EV growth in India if several conditions are met, including the introduction of government mandates and subsidies, policy frameworks that guarantee interoperability and safety, and battery swapping roadmaps for different segments, from 2Ws and 3Ws to e-commercial fleets. They also believe that swappable batteries would be half the size, require less lithium, last longer, and allow for better grid management compared with batteries individuals charge at home (Charan 2022). Moreover, experts consulted for this study suggested that swapping stations could reduce the sizable land requirements of charging infrastructure because they can be set up in stores and lengthen the lifetime of the batteries because they would be charged in a controlled environment.

Several recent announcements in India indicate progress in the battery swapping realm:

- The EV manufacturer Mahindra and the oil company Reliance Industries will develop battery swapping technology for food delivery fleets of the online food ordering and delivery company Swiggy (Mishra 2021).
- The motorcycle company Hero MotoCorp and scooter company Gogoro will open a network of swap stations (Gogoro 2021).
- The energy company Sun Mobility and Honda will set up a battery sharing and swapping business (Balasubramanyam 2022).
- The electric 2W company Bounce and parking solutions platform Park+ will set up 3,500 battery swapping stations (Economic Times 2021).
- Yulu is expanding its battery swapping network in Bengaluru, Mumbai, and Delhi NCR (Livemint 2021).

The Indian government has started to develop a policy framework to facilitate battery swapping. The current finance minister announced that the government will formulate interoperability standards for EV batteries, focusing specifically on electric 2Ws and 3Ws and targeting the last-mile delivery and ridesharing segments. Recent media reports suggest that the government is also likely to offer EV owners an incentive of up to 20 percent of the total subscription or lease cost of the battery and is considering cutting taxes from the aforementioned 18 percent rate to the 5 percent that is applicable to fixed batteries (Shah 2022).

# 6.0 Takeaway 5

## India is a young player in battery manufacturing, but its growth potential in this space is enormous.

The global lithium-ion battery (LIB) market is expected to grow from about $41 billion in 2021 to at least $116 billion in 2030 (Invest India 2021). The battery represents the largest share of an EV's value, at around 40 percent (Invest India 2021). Within the battery, the battery cell has the highest value (see below). In a rapid growth scenario, India expects an annual battery market of approximately $15 billion by the end of the decade, of which about $12 billion would come from cell manufacturing and $3 billion from battery pack assembly and integration. Even in a conservative scenario, the Indian domestic manufacturing market would be worth $6 billion annually (NITI Aayog, RMI, and RMI India 2022b).

The volume of LIB manufacturing among the countries leading this sector is likely to change. Currently, China holds about 78 percent of battery manufacturing capacity, followed by the US (8 percent) and the EU (7 percent). But high levels of demand growth are opening up new initiatives and production capacity worldwide, which will inevitably increase competition. By 2025, it is expected that China's share of LIB manufacturing will fall to 65 percent, while the EU's share will increase to 25 percent (NITI Aayog, RMI, and RMI India 2022b). Other countries such as India are also expected to increase their share.

NITI Aayog, RMI, and RMI India (2022b) expect that by 2025 the price competitiveness of electrified 2Ws, 3Ws, and buses will reach parity with ICE vehicles. By 2030, they expect the same to be true of electric 4Ws. Whereas today the 2W and 3W segments have the most potential in India, by the end of the decade, other segments will have grown rapidly too. EV sales penetration of commercial 4Ws, for instance, is expected to be between 30 percent and 40 percent by 2030, while in an accelerated scenario, as high as 70 percent of new sales could be electric. Electric buses are expected to be third, with a conservative sales penetration rate of almost 20 percent and an accelerated penetration rate of 40 percent. Currently, state transport agencies are incentivizing intracity electric buses through tenders, while intercity bus routes are often covered by private companies that may delay electrification due to the large distances they cover. The sales penetration rate of private 4Ws is expected to be 5–10 percent in a conservative scenario and 10–15 percent in an accelerated scenario (NITI Aayog, RMI, and RMI India 2022b).

These EV numbers imply very strong demand growth for batteries. NITI Aayog and the Rocky Mountain Institute believe that with a high penetration of EVs India could capture 13 percent of worldwide LIB demand by 2030 (NITI Aayog, RMI, and RMI India 2022b). While it is true that 2W and 3W batteries are smaller and have somewhat less value than 4W batteries, the scale of electrification of 2Ws in India, in combination with the uptake in commercial 4Ws and buses (which require much larger batteries), will spur demand growth.

To meet that demand with locally sourced manufacturing, India would need to install two 10 GWh battery-cell gigafactories by 2022, five by 2025, and 26 by 2030. In a conservative scenario, the country would need 10 such factories by 2030 (NITI Aayog, RMI, and RMI

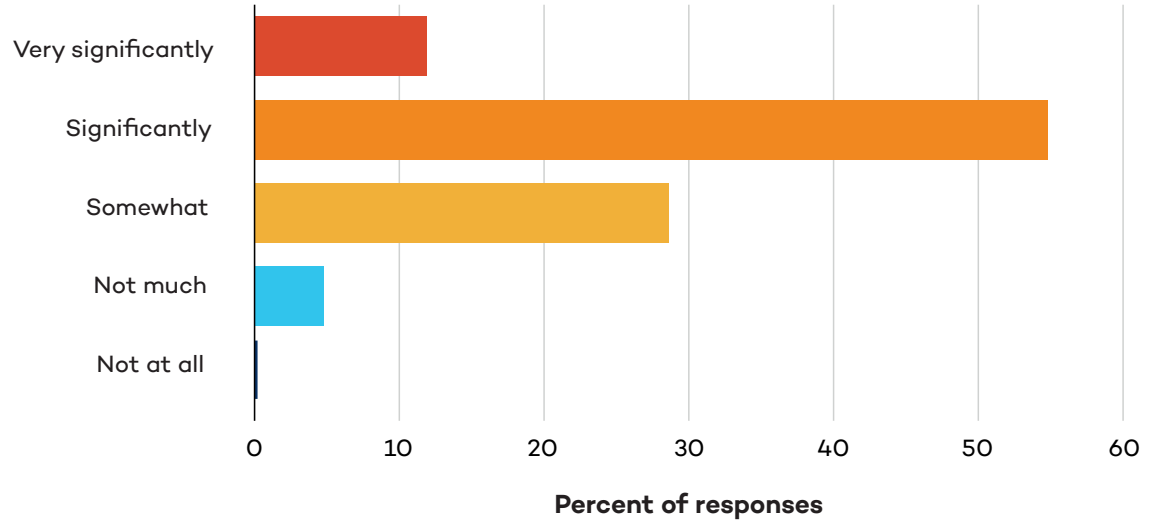
India 2022b). Currently, India is not yet a large player in battery manufacturing, but the market potential for this manufacturing is enormous, and the sheer size of future demand should allow for economies of scale.

India's core industrial policy measure to incentivize battery manufacturing is its Production Linked Incentive Scheme for Advanced Chemistry Cell Batteries (PLI-ACC). Launched in 2021, the PLI-ACC is intended to incentivize domestic battery manufacturing. The scheme foresees $2.5 billion of subsidies over five years, which will be awarded to battery manufacturers through a competitive bidding process with the ultimate goal of establishing 50 GWh of local manufacturing capacity.

The subsidy amount is determined based on the amount of kWh, the percentage of local value addition achieved, and the actual sale of batteries (Invest India 2022). Within the first two years, winning bidders will need to set up at least 5 GWh of capacity, source 25 percent of value domestically, and undertake an investment of $31 million per GWh. The domestic content requirement then increases to 60 percent within five years (Government of India Department of Heavy Industry 2021a). While initially companies will be able to enjoy the subsidy by localizing battery assembly, the 60 percent domestic content requirement makes it mandatory for the manufacturing of battery cells to happen in India within five years.

Experts and investors strongly believe the PLI-ACC and PLI Auto schemes (see below for more detail on the latter) will accelerate the EV ecosystem in India (see Figure 5).

**Figure 5.** To what extent do you think the PLI-ACC & PLI Auto schemes will accelerate the EV ecosystem in India?




Source: Authors' survey.

The cost of a battery can be divided into cell manufacturing (65 percent) and assembly (35 percent) (Invest India 2021). Within the cell, 35 percent of the value comes from the cathode, 15 percent from the anode, 25 percent from cell assembly, and 25 percent from other activities and parts, specifically the separator (ibid.). The cathode is cast on aluminum foil and requires raw minerals such as manganese, nickel, cobalt, and lithium. The anode, by contrast, is cast on

copper foil and requires graphite. Given that India has plenty of graphite, domestic production of anodes is not at risk from a material supply perspective (ibid.). Investment is needed, however, to build industrial capability and know-how to process graphite into the high-purity graphite used in anodes. The domestic production of cathodes, meanwhile, faces considerable supply chain challenges (see below).

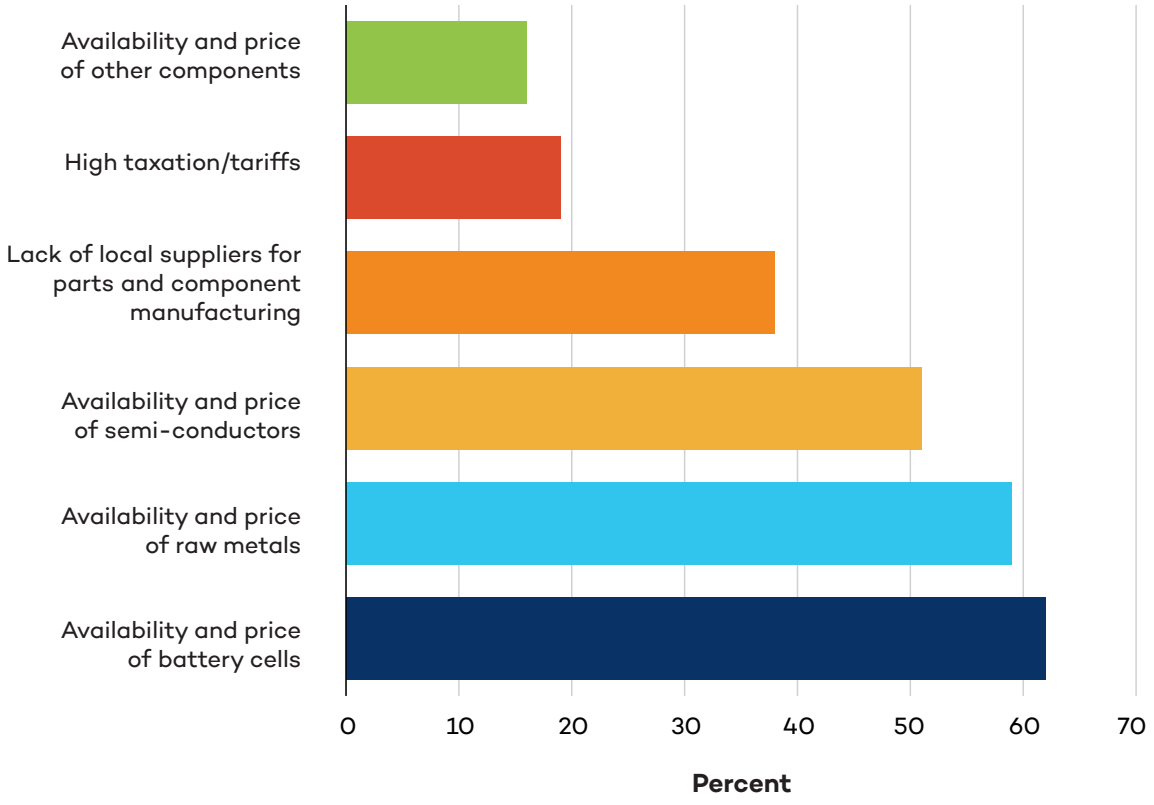
The first bidding round after the initiation of the scheme requested bids for a total of 50 GWh of ACC manufacturing. Companies had to bid for at least 5 GWh and a maximum of 20 GWh of manufacturing capacity. The scheme received an encouraging response from both local and global investors. The tender was oversubscribed, and the government received bids of 130 GWh for a PLI-ACC tender size of 50 GWh. Three companies were selected to boost local battery cell production: Reliance, Ola Electric, and Rajesh Exports (Government of India Ministry of Heavy Industries 2022).

# 7.0 Takeaway 6

## Supply chain challenges can derail the rapid upscaling of EV and battery investment, highlighting the need for stronger policy support.

Beyond concerns about competition, India faces considerable energy security and supply chain challenges related to importing automobile components, battery cells, and other components such as semiconductors. Currently, China holds around 75-80 percent of raw battery material refining and global battery cell manufacturing capacity, and Taiwan accounts for well over half of global semiconductor manufacturing capacity (Nee Lee 2021). Given India's geopolitical tensions with China, a rapid uptake of EVs in the country (and worldwide) would require a more diversified supply base. Consulted experts and investors highlighted that the top three supply chain concerns in India are indeed linked to the availability and price of battery cells, raw metals, and semiconductors (see Figure 6).

**Figure 6.** What supply chain concerns does the Indian EV ecosystem face today?




Note: Participants indicated agreement or disagreement with each statement as a concern in the current Indian EV ecosystem; the percentage noted here corresponds to agreement.

Source: Authors' survey.

## 7.1 Battery raw materials

India's ambition to become a battery cell manufacturer has been thwarted by global supply-side constraints that affect Indian producers. As mentioned, cathode manufacturing requires aluminum, cobalt, lithium, premium grade nickel, and manganese. There are considerable supply-side challenges for each of these critical minerals.

The most well-known of these supply-side challenges is linked to cobalt. More than half of the worldwide reserves of cobalt and more than two-thirds of its production are in the Democratic Republic of the Congo (DRC). Cobalt production in the DRC has been plagued by corruption, fraud, and human rights violations. As a result, many battery manufacturers have been cutting the proportion of cobalt they use in batteries and have even been omitting the metal altogether (Moerenhout 2021a).

Unlike cobalt, lithium is likely to remain a key battery ingredient for the foreseeable future (Castelvecchi 2021). As with other key metals, lithium supply is not expected to meet demand over the next few years, specifically owing to the uptake of EVs (Yue Li and Attwood 2021). Lithium resources are also concentrated in a handful of countries, specifically Australia and the lithium triangle in South America. Bolivia and Chile hold among the largest lithium resources worldwide—21 million tons and 10 million tons, respectively, out of a global total of 86 million tons. Nevertheless, the processing of lithium is not well advanced in either country. For example, Chile holds 44 percent of the commercially viable lithium reserves worldwide but produces only about 22 percent of the world's lithium (USGS 2021). Despite having more resources, Bolivia mines and processes even less lithium, with its reserves not yet considered economically viable.

Nickel is used in batteries because of its high energy density, which allows for a lower share of cobalt. Although nickel is abundant worldwide, the class-one, high-grade nickel that is comprised of more than 99.8 percent nickel and allows a battery to be more durable and deliver a longer range (Assay 2021) will be more difficult to supply in the coming decade, especially given the demand competition from the stainless-steel industry (Azevedo, Goffaux, and Hoffman 2020). Already in 2021, there were concerns that the high-grade nickel supply could be insufficient to meet demand (Baratti 2021). This gap is expected to grow due to insufficient high-grade nickel-mining projects to keep up with forecasted demand (Liedtke 2021a; Rystad Energy 2021). Given that Russia supplies 20 percent of EV battery-grade nickel, the Russian war in Ukraine is putting additional pressure on nickel supply and prices (Finley 2022).

In response to insufficient nickel supply, evolving battery chemistries seek to lower the nickel content of batteries and increase the manganese content (from 10 percent to around 30 percent) or use iron phosphate batteries made available by improvements in energy density over the last few years (Rystad Energy 2021). While mining for manganese is relatively simple and supply is found in more than 10 countries considered politically stable, refining it to battery-grade manganese sulfate is both expensive and technologically complex (Liedtke 2021b). Currently, 90 percent of the global capacity for the production of high-purity manganese sulfate is in China. While some processing plants outside of China are underway, many more will be needed to diversify supply (ibid.).

The Indian government's response to battery mineral supply challenges has been twofold. On the one hand, some government-affiliated experts have suggested that beneficiaries from the PLI-ACC scheme should pass on benefits to raw material suppliers (Iyengar 2021). On the other hand, the government is developing forward-looking policies and incentives to promote "urban mining," which involves recycling LIBs to retrieve and reuse key metals.

Battery recycling can help secure raw material supplies and protect against cost escalation in the medium term. Besides China, which is the leader in LIB recycling, the United States and Europe are enacting policies and incentives to encourage this practice. For example, the EU has proposed a new battery directive that specifies minimum recycled content requirements for battery minerals. Given the success of the PLI-ACC scheme, the Indian government is well positioned to follow suit. Consulted experts suggest that Indian cell makers can be potential joint venture partners for the global recycling companies that access the Indian market.

Nevertheless, many consulted investors believe that the Indian government should also play a more active role in helping secure semiconductors and primary metals for cathode manufacturing. Battery reuse as cheap energy storage can delay battery availability for recycling, and in any case, it will take time to get battery recycling processes up and running. Simultaneously, localization requirements in the PLI-ACC scheme require cathode manufacturing within five years. As a result, investors want the government to engage more actively in setting up international collaborations that can get strategic components and metals to India. For example, some experts have suggested that India could acquire stakes in lithium mines in Bolivia (Dash 2021). The state-owned company KABIL is already working with the biggest lithium-supplying countries (Australia and Chile) and lithium resource-rich countries (Bolivia, Chile, Argentina, and Australia) to take the first steps toward such international cooperation (Hector 2021).

## 7.2 Semiconductors and nonbattery components

Like many other countries, India is seeking to capitalize on the global semiconductor shortage by constructing a mega semiconductor cluster. At the end of 2021, the cabinet approved the Semicon India Program, which sets up packages of upwards of $10 billion over the next six years to incentivize domestic semiconductor and display manufacturing in India. By mid-February 2022, the government had already received five proposals representing a total potential investment of around $21 billion (Bhardway and Cyrill 2022). Reportedly, the government is also in talks with Taiwan to facilitate international cooperation on semiconductor-manufacturing capacity (Rajagopalan 2022).

To minimize supply chain challenges beyond batteries and semiconductors, the Indian government approved the PLI Scheme for Automobile and Auto Components Industry (PLI Auto) in 2021 with a budgetary outlay of $6.5 billion. This production-linked incentive scheme focuses on nonbattery components (with batteries being covered by the aforementioned PLI-ACC scheme) and includes incentives for green vehicles (electric and hydrogen) and high-value advanced automotive technology products. In addition to incentivizing auto OEMs and auto components, the PLI Auto supports non-automotive companies that seek to foray into green mobility (Government of India Department of Heavy

Industry 2021b). The scheme is estimated to bring fresh investments of over $10.5 billion that will assist in rapidly building a local EV and EV-component manufacturing ecosystem in India (Mukherjee 2022).

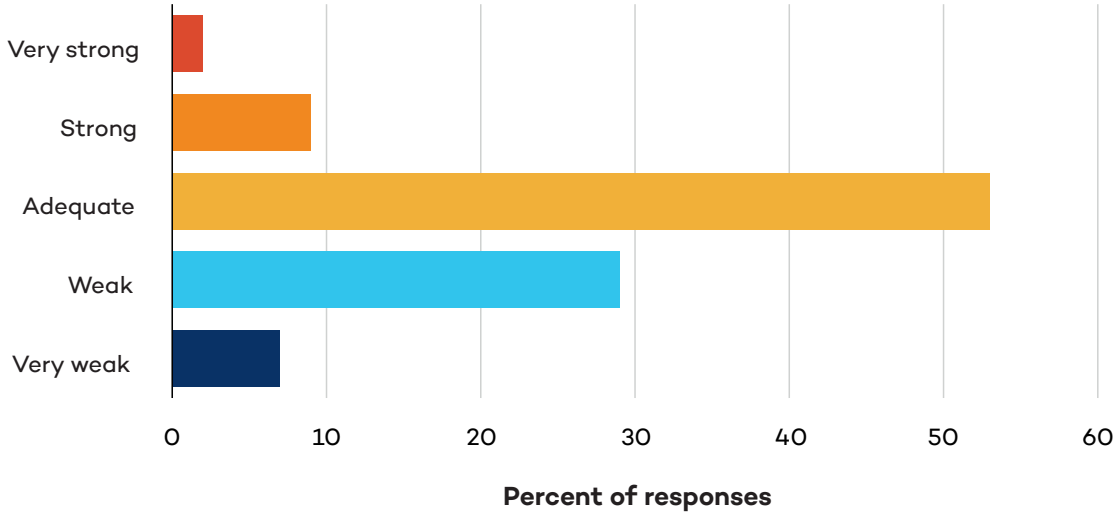
In January 2022, the Indian government received a clear signal that investors were ready to participate in the PLI Auto when 115 companies responded to its call for proposals. The Ministry of Heavy Industries approved 20 Auto OEMs as eligible for incentives. Of these 20 OEMs, 10 are incumbent 4W manufacturers, and 6 are non-auto companies that plan to begin manufacturing EVs under the PLI Auto scheme (Mukherjee 2022).

# 8.0 Takeaway 7

## India has taken sound steps to incentivize EVs and battery manufacturing since the start of COVID-19, but the competition is stark.

The EV ecosystem in India has space to be competitive globally, but the competition is stark. Several governments around the world have used the COVID-19 crisis as an opportunity to extend fiscal policies that incentivize EV uptake and battery manufacturing. India's key programs, FAME II and the PLI-ACC, compare favorably with these policies in terms of fiscal incentives for EV purchases and battery manufacturing. As mentioned earlier, they lag behind, however, on charging infrastructure, even as FAME II has allocated $130 million to developing it. Despite this challenge, half of the experts consulted for this study believe that India's EV ecosystem policies are now adequate compared with other major EV ecosystems, indicating that the country is ready to receive more FDI and is on track to becoming a mature EV ecosystem (see Figure 7).

**Figure 7.** Compared to other major EV ecosystems (e.g., Europe and China), how competitive are India's current EV policies in attracting investment?




Source: Authors' survey.

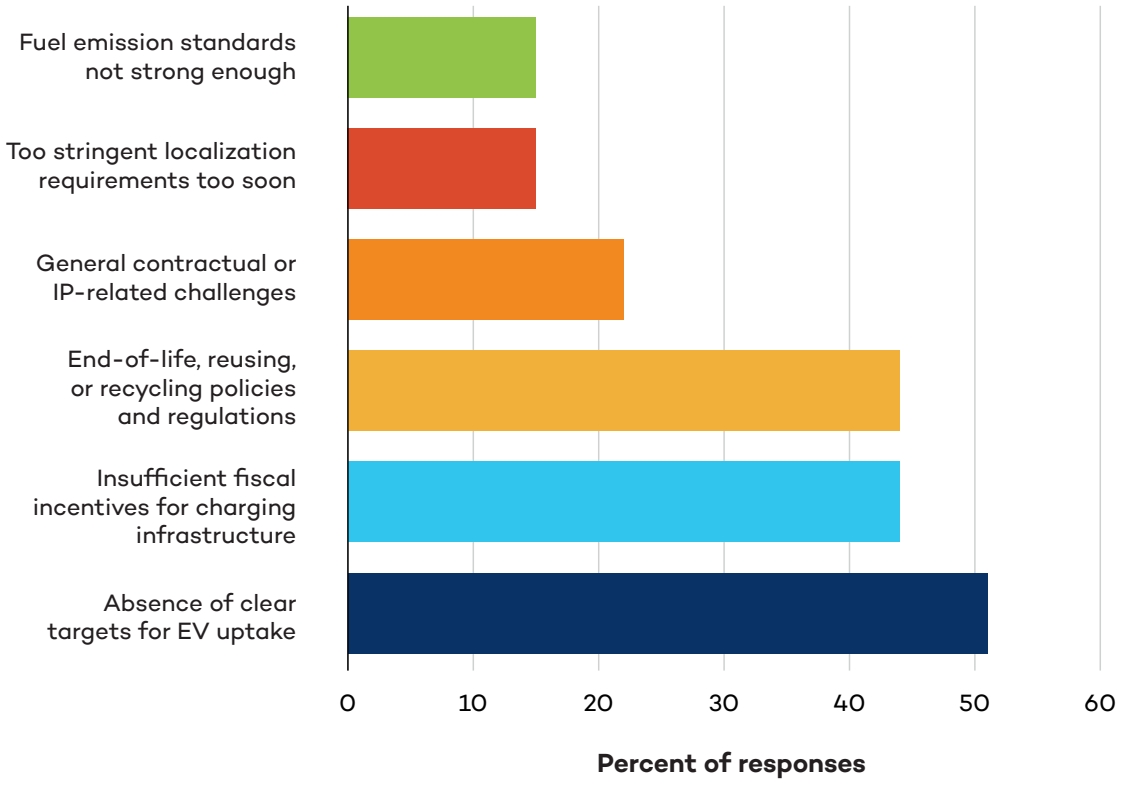
Some of the largest approved commitments outside of India are (Energy Policy Tracker 2022):

- **China:** $1.6 billion for EV purchase subsidies and $1.5 billion for charging infrastructure
- **US:** $7.5 billion for charging infrastructure, with several states adding more on top
- **Canada:** $1.1 billion for zero-emission buses and charging infrastructure
- **EU:** $750 billion recovery fund that allows member states to request charging infrastructure support, plus $3.2 billion for pan-European research and development (R&D) along the entire battery value chain

- **Germany:** $2.7 billion to double EV purchasing premiums and $2.9 billion to extend charging infrastructure
- **UK:** $1.7 billion for charging infrastructure, $800 million for zero-emission vehicles purchase subsidies, and $700 million for battery manufacturing
- **France:** $600 million for EV purchasing subsidies and $800 million for battery manufacturing
- **Italy:** $800 million for charging infrastructure

India has certain advantages over these countries, including its sheer domestic market size, its digital competitiveness, the size of its skilled workforce, and its wage competitiveness. Consulted investors suggested that India could further improve its competitiveness by moving from enabling policies to binding targets. Localization targets are included in the PLI-ACC scheme, and failure to achieve them will invoke penalties. Extending targets to include binding EV penetration targets and vehicle emission standards would demonstrate the government's commitment to electrification over the long run and help leverage India's market size (see Figure 8).

**Figure 8.** Select a maximum of three policy barriers to upscaling investment in electric mobility in India.




Note: Survey particiants selected up to 3 barriers from a list of 9.
Source: Authors' survey.

The world's major EV ecosystems have begun to adopt strong targets—most importantly for market penetration. At COP26, 28 governments announced the goal of 100 percent zero-

emission car and van sales by 2040, or even 2035 in the case of leading markets (COP26 2021). In its Fit for 55 program, the EU proposed a 100 percent zero-emission car and van sales target for 2035 (European Council 2022). In the United States, certain states, such as New York and California, are adopting similar targets (Moerenhout 2021b). China has already implemented zero-emissions vehicle credit targets for manufacturers as a share of their total annual vehicle production. By 2023, manufacturers in China will need to ensure that 18 percent of their sales in the country correspond to so-called new energy vehicles, such as battery EVs or plug-in hybrids. China has also banned ICE versions of 2Ws and 3Ws in numerous cities.

Another frequently used policy to incentivize EVs is the gradual tightening of fuel economy standards. India still lags somewhat behind the other major EV manufacturers on this front. Similar to Japan, it has a 134 g CO2/km cap. By comparison, China, the United States, and Canada have a 114–117 g CO2/km cap, and the EU has an average 95 g CO2/km cap among its member countries (IEA 2021a).

Other measures to incentivize demand include car plate restrictions with EV direct access, traffic restrictions with EV waivers, and low cost or free parking for EVs. These measures have been used in several major Chinese cities and are being considered in multiple countries (IEA 2021a). In India, they could amplify demand in heavily dense urban settings while simultaneously showing investors that certain deployment bottlenecks can be overcome. Currently, while 59 percent of consulted experts and investors believe that there is near- and long-term ambition for EV adoption and ICE phase out, about half still see an absence of clear targets for EV uptake, which they suggest is the largest policy barrier alongside insufficient fiscal incentives for charging infrastructure to upscaling investment in electric mobility in India (see Figure 8). The investors appear to believe that such targets are far more important than fuel emission standards and stringent localization requirements.

# 9.0 Takeaway 8

## Complementarity between state and federal policies is crucial, with some states ahead of others.

If India wants to develop its EV ecosystem, complementarity between federal, state, and local policies is key. As of February 2022, about 18 Indian states have developed final EV policies, with eight more states in the process of doing so. About two-thirds of consulted experts and investors do not believe that coordination between state and federal policies is a particularly urgent policy barrier. However, 39 percent believe that difficulties at the local level to support required infrastructure (e.g., land for charging and local permits) do represent a key infrastructure barrier. If the goal is to alleviate those concerns, linking local policies to state and federal EV policies can be effective.

The question of which states in India are leading the EV charge has no clear answer. For instance, on the adoption front, northern states such as Uttar Pradesh are ahead of the curve, though Delhi is quickly catching up with a very comprehensive state EV policy that focuses heavily on EV adoption. The picture is completely different for manufacturing, however, where the key is the investor checklist rather than large demand-side incentives alone. This checklist includes the status of the manufacturing ecosystem, state proactiveness in handling investor queries and continuous investment facilitation support, political stability and long-term sanctity of contracts (promised incentives), dedicated EV policies and incentives as well as capital subsidies from the state, access to port infrastructure for importing raw materials and exports, and the availability of a skilled workforce. Some consulted investors also ask for access to renewable energy to make batteries and vehicles even stronger from an ESG perspective.

Based on these factors, states in southern India, such as Telangana, Karnataka, and Tamil Nadu, in addition to Maharashtra and Gujarat in the west, appear to be at the forefront of the EV manufacturing race. These states are also proactively and regularly engaging with central government bodies, such as NITI Aayog and Invest India. That many of these state governments have also taken the initiative to start engaging with bidders in the previously mentioned PLI Schemes is a testament to their hands-on approach. If states wish to build competitive industries, they will also need to focus on their competitive advantage in the EV value chain. For example, Karnataka accelerates the R&D ecosystem that it is already known for, whereas Maharashtra could build on its sizable manufacturing advantage.

Some states are using new approaches to incentivize the creation of an EV ecosystem, such as the exceptional step of investing directly in EV companies. One example is the recent joint venture partnership between the Kerala state government and Lord's Automotive to manufacture EVs in the state. Other states, such as Telangana, are offering a full suite of options to promote technology-development startups, from financing to prototyping centers to business incubators.

# 10.0 Takeaway 9

## If the goal is to ensure a smooth transformation to a healthy EV ecosystem, some skill gaps still need to be addressed in the medium term.

As the transition from ICE automobiles to EVs accelerates in India, there is growing concern about the skill differential between these two segments, especially given that the automotive sector is one of India's largest employers for both direct and indirect employment. If the goal is to avoid job losses due to this transition, initiatives to retrain the labor force are required.

The skill gap issue varies in degree and extent across the EV supply chain. For instance, there is almost no skill gap for workers with an understanding of chemicals. On the other hand, companies face problems in securing workers skilled in R&D. Issues surrounding labor in the EV sector are also not limited to the manufacturing and assembly of EV components and vehicles. Since EVs require safety precautions, certain professionals outside of the periphery of the conventional EV supply chain are likely to come in contact with EVs, including shopfloor workers and individuals servicing and repairing EVs. These professionals, many of whom are part of the informal sector and only have experience with ICE vehicles, will need training too. It is important to recognize, though, that even with measures to close the skill gap, some job losses may occur because EV mechanics and maintenance are simpler than their ICE vehicle equivalents. Averting these losses will likely require a more elaborate, just transition pathway.

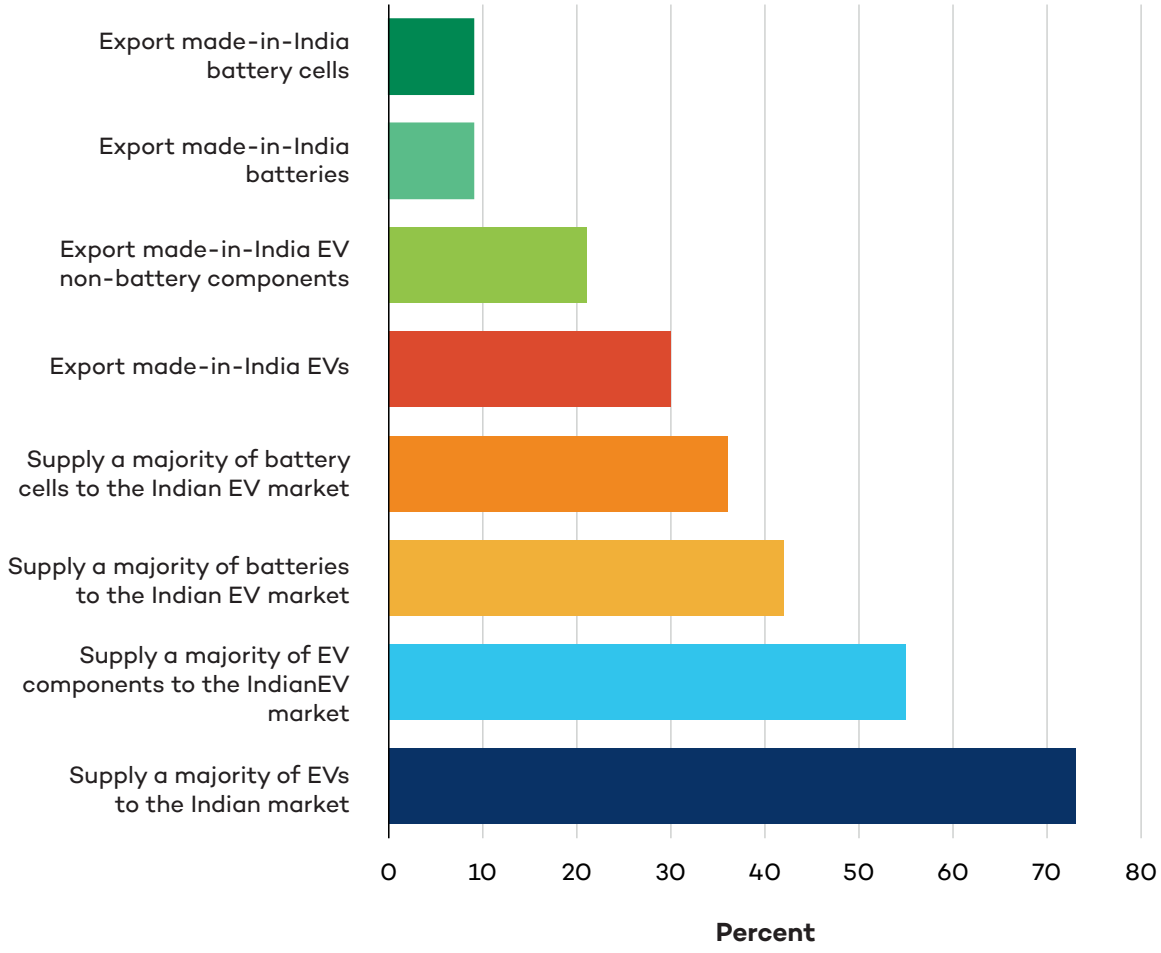
Government, industry, and academia in India have each responded to the skill gap problem. Industry and academia have sought to retrain the workforce and launch education courses, while state governments have sought to support them. For example, Maharashtra introduced a policy that supports amending existing courses or creating new courses on EV ecosystems. In collaboration with OEMs and EV service providers, the state government plans to develop skill enhancement centers to deliver vocational courses linked to the EV ecosystem. Specifically, these centers would train ICE mechanics to repair and service EVs and charging stations. Similarly, Karnataka aims to establish EV skill development centers that, in addition to technical training, will offer a stipend for workers to gain experience at EV manufacturing plants, and Tamil Nadu aims to introduce EV engineering courses in partnership with OEMs that will provide internships to students (Ray et al. forthcoming).

# 11.0 Conclusion

If India (and the rest of the world) seeks to meet its decarbonization goals, expanding the country's EV penetration rate is crucial. Even when powered by coal-fired electricity, EVs produce fewer carbon emissions per kilometer than their ICE counterparts. Additionally, India's timescale for the deployment of EVs is well aligned with plans to deploy 500 GW of renewable energy by 2030.

As this report has shown, recent policy initiatives in India are preparing the country to leverage its market size to become a global EV investment destination. Consulted experts and investors expect that India will do so by, first, supplying the domestic market with EVs and EV nonbattery components, and then, within three to five years, making strides in battery assembly at the initiative of investors and companies. The experts and investors do not expect battery cell manufacturing to reach its full potential in the country just yet (see Figure 9).

**Figure 9.** In 3 to 5 years, India-based manufacturing will




Note: Participants indicated agreement or disagreement that each outcome was likely to occur in the next three to five years; the percentage noted here corresponds to agreement.

Source: Authors' survey.

It should come as no surprise, then, that India's EV market is projected to be worth $150 billion by 2030 (Invest India 2022). As discussed in this report, federal policies such as FAME II, PLI-ACC, and PLI-Auto have created a strong environment for a globally competitive EV ecosystem in India, specifically in the 2W and 3W segments. Eighteen Indian states have also added new incentives to the mix that can help India bolster demand for 4Ws and electric buses as well as host megafactories.

This report also highlighted that, like in other countries, legacy issues such as concerns over the high purchase costs of EVs and limited public awareness about the total cost of ownership and available incentive mechanisms remain important in India. Although the country is working actively to improve financing options, if it seeks to pave the way for broader EV uptake, it will need to accelerate these efforts. Consulted investors believe that lessons can be learned from experiences in other countries, particularly those that have moved from an enabling policy environment to specific targets and other regulatory instruments to incentivize demand and supply chains. India's growing EV market penetration and battery-development ambitions also introduce new barriers, including supply-chain worries related to the price and availability of semiconductors, metals and minerals, and battery cells, as well as concerns about insufficient charging infrastructure and electricity grid readiness.

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