ORF

d·i·e

Deutsches Institut für Entwicklungspolitik

German Development Institute

Electric Buses in India

Emerging Issues and Policy Lessons

Promit Mookherjee and Kushan Mitra

Attribution: Promit Mookherjee and Kushan Mitra, *Electric Buses in India: Emerging Issues and Policy Lessons*, March 2022, Observer Research Foundation.

Observer Research Foundation
20 Rouse Avenue, Institutional Area
New Delhi 110002
India
contactus@orfonline.org
www.orfonline.org

The Observer Research Foundation (ORF) provides non-partisan, independent analyses and inputs on matters of security, strategy, economy, development, energy and global governance to diverse decision-makers (governments, business communities, academia, and civil society). ORF's mandate is to conduct in-depth research, provide inclusive platforms, and invest in tomorrow's thought leaders today.

This report was prepared by ORF with support from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the German Development Institute (DIE). The study is part of a larger collaborative international project of the DIE and the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC). The recommendations and the views expressed herein are, however, those of the researchers and do not reflect the formal position of the supporting organisations.

The German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) is one of the leading research institutes on development policy. Through excellent research, policy advice and training, the Institute contributes to finding solutions to global challenges.

Design: Rahil Miya Shaikh

Layout: Simijaison Designs

Contents

Introduction

In most developing countries, public transport is the primary means for people to access employment, community resources, medical care, and recreation. In India, public buses remain the most affordable means of travel and an enabler of economic activity. According to a survey by the Ministry of Statistics and Programme Implement ation (MoSPI) in 2015, about 66 percent of households in urban areas reported expenditure on buses to be the highest among all modes of travel that they used. The monthly per capita expenditure was also found to be highest for buses in both urban (INR 94.89) and rural areas (INR 43.43).[1]

The modal share of public transport in India has historically been high. However, public transport infrastructure in Indian cities has failed to keep pace with population growth in these urban spaces.[2] The bus fleet, for example, remains highly inadequate. A NITI Aayog study in 2018[3] estimated that India has only 1.3 buses for every 1,000 people, much lower than other developing countries such as Brazil (4.74 per 1,000) and South Africa (6.38 per 1,000).[4] The lack of buses has led to commuters increasingly moving away from public transport. The erstwhile Ministry of Urban Development (MoUD)—now the Ministry of Home and Urban Affairs (MoHUA)—had sanctioned two comprehensive mobility studies—one in 1994, and another in 2007. The decline in the modal share of public transport in the period between the two studies highlights the changing preference of Indian commuters (See Table 1).[5] The drop is most evident in the larger cities, in some cases like Delhi as high as 25 percent. The severe shortage of buses has increasingly pushed commuters towards personal transport. Indeed, India is the world's largest market for two-wheelers, which are significant contributors to increased traffic congestion, greenhouse gas emissions, and the worsening of air pollution.[6]

Table 1: Changing Modal Share of Public Transport in Indian Cities

City Category	Population Range (in lakhs)	Public Transport Share (%)	
		1994	2007
1	<5.0	14.9 - 22.7	0 - 15.6
2	5.0-10.0	22.7 - 29.1	0 - 22.5
3	10.0-20.0	28.1 - 35.6	0 - 50.8
4	20.0-40.0	35.6 - 45.8	0.2 - 22.2
5	40.0-80.0	45.8 - 59.7	11.2 - 32.1
6	Above 80.0	59.7-78.7	35.2-54.0

Source: Ministry of Housing and Urban Affairs (MoHUA), 2008

At the same time, the continued reliance of the riding public on the current fleet of buses brings with it certain environmental challenges. For one, buses plying India's streets are almost exclusively dependent on diesel, accounting for 10 percent of total diesel consumption in the country.[7] According to estimates from the India GHG program, a bus in an urban area in India emits on average 0.015 kg CO2 per passenger-kilometer.[8] Publicly owned buses cover 566 billion passenger-kilometers annually, within and across cities[9]—this translates to some 8 million tons of CO2 emissions from publicly owned buses, which account for only 7 percent of the total bus population.[a] Furthermore, only one percent of

a Assuming the same emission factor for intra and intercity operations due to lack of separate estimates. This is likely to be a slight overestimate since fuel efficiency for intercity operations may be slightly higher.

registered buses conform to the latest air pollutant emission norms (Bharat Stage-VI).[10]

The deployment of electric buses is seen as an opportunity to decouple the negative externalities of bus travel from the augmentation of a currently inadequate fleet. In particular, e-buses can be an effective solution for the intra-city segment where the daily travel range is low and planning for recharging infrastructure is easier. Unlike their ICE (internal combustion engine) counterparts, electric buses have zero tailpipe emissions, lower noise pollution, and are touted to provide a better commuter experience. As a result, these buses have been receiving a large push from policymakers at both national and sub-national levels. In many ways, electric buses have brought back attention to the historically neglected public bus service, with many state governments announcing electric bus procurement programs. However, the market for electric buses today is not market-driven but defined by purposive government policies, in terms of both demand and supply. This study aims to assess the current policy focus for electric buses and identify implementable lessons for the future.

The first part of the study deals with the challenges associated with the high capital investments needed for electric buses compared to their ICE counterparts. Thus far, the uptake of electric buses in India has been driven by government subsidies directed only towards publicly owned enterprises. This report aims to assess whether the present strategy can ensure an effective long-term uptake of electric buses in the country. Further, it is important to ensure that diverting public resources for electric buses does not result in reduced funding for the broader improvements needed in the public bus system. To this end, the report evaluates the trade-offs associated with investment in electric buses and identifies implementable policy lessons for the future.

The second part of the study explores the implications of the electric mobility transition on the manufacturing ecosystem. At present, the ICE-based manufacturing ecosystem contributes significantly to the economy in terms of value added and employment generation. The economic co-benefits from the transition to electric vehicles will depend on the ability to build up domestic production capabilities to reduce imports, create new businesses, and generate employment. This will require a favourable industrial policy that can accelerate innovation and incentivise firms to channel resources to building up local capabilities. In this context, the study analyses the present industrial policy on electric vehicles, with a particular focus on buses. It evaluates the present status of the electric mobility manufacturing landscape, highlighting the implications for national value added, employment generation, and raw material dependence.

The study relies on policy documents, data from secondary sources, existing literature on the subject, and extensive consultations with stakeholders including government officials, automobile manufacturers, industry bodies, and private research organisations.[b]

The deployment of electric buses is seen as an opportunity to decouple the negative externalities of bus travel from the augmentation of a currently inadequate fleet.

b All interviews were done without attribution, to ensure a candid exchange of views. The participants in these consultations are listed in the Annex.

Policy Scenario for Electric Buses

In 2013, the Central government launched 'The National Electric Mobility Mission Plan (NEMMP)' to be administered by the Department of Heavy Industries (DHI). Not too long after, in 2015, DHI launched the 'Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME)' Scheme with an initial outlay of INR 7.95 billion. FAME's mandate involves demand creation, technology proliferation, the launch of pilot projects, and building charging infrastructure. During the first phase of FAME (2015-2019), 465 electric buses were sanctioned to be distributed to different cities. A few years later, in 2019, FAME-II was announced, with a much larger outlay of INR 100 billion for three years. (See Table 2 for the planned allocation of funds.) The largest outlay was for demand incentives, followed by charging infrastructure and administrative expenditure.

Buses have been identified as a key segment for subsidies within FAME-II, with an allocation of INR 35.45 billion for supporting 7,090 e-buses (See Table 3). Electric buses receive a subsidy of INR 20,000/KWh of battery capacity, double the amount for most other segments. The maximum incentive for a bus is pegged at INR 5 million, with the scheme covering only buses with an ex-factory retail price below INR 20 million. Critically, FAME subsidies are provided only to state-run agencies, and not to private bus operators.

Table 2: Funds allocation for FAME-II (in INR billion, including all vehicle types)

Component	2019-20	2020-21	2021-22	Total
Demand Incentives	8.22	45.87	31.87	85.96
Charging Infrastructure	3.00	4.00	3.00	10.00
Administrative expenses	0.12	0.13	0.13	0.38
Total for FAME-II	11.34	50.00	35.00	96.34

Source: Department of Heavy Industries (DHI)

Thus, the transition to electric buses is limited to the organised public bus system where the key players are the State Road Transport Undertakings (SRTUs). Further, subsidies are only provided for operational expenditure (OPEX) based financing, not outright purchases. This has led to widespread adoption of the gross cost contract (GCC) or 'wet lease' approach to procuring e-buses, where the public agency retains control over the farebox revenues and pays a fixed fee per km to an external contractor to procure and operate the electric buses. The external contractor has to involve an Original Equipment Manufacturer (OEM) that manufactures e-buses. The OEMs can choose to bid for the tenders alone or in partnership with an operator who will carry out the day-to-day operations. The subsidy on each bus is then directly credited to the OEM by DHI.

Till August 2022, DHI had sanctioned 6,265 electric buses across 65 cities, SRTUs, and States.[11] Of these, a supply order has been placed for 3,118 electric buses. This is in addition to the 425 electric buses which have already been procured and deployed as part of FAME-I. However, there is a considerable lag between the time of placing supply orders and actual deployment, as tenders carry complicated conditions. As per the Vahan Database, there were 1,527 electric buses registered between April 2019 and January 2022.[c] This accounted for only 2 percent of

c This does not cover some states which are not yet integrated with the Vahan Database.

the newly registered buses in the same period. However, it must be noted that annual bus sales since 2020 have been less than 50 percent of the annual sales before the pandemic.

Table 3: Incentives, by Vehicle Segment

Vehicle Segment	No. of vehicles supported	Recommended battery size (KWH)	Approximate incentive per KWH of battery (INR)	Maximum ex-factory price (INR)	Total Fund allocation (INR)
Two-wheelers	10,00,000	2	15,000	150,000	20 billion
Three-wheeler	5,00,000	5	10,000	500,000	25 billion
Four-wheeler	35,000	15	10,000	1.5 million	5.25 billion
Bus	7,090	250	20,000	20 million	35.45 billion

Source: Department of Heavy Industries (DHI)

Additionally, 13 states have notified their EV policies and many more are in different stages of the process. All the state policies provide purchase subsidies in addition to the central subsidies. The level of subsidy differs across states and across vehicle segments. Only a few states have provided additional subsidies for buses and the amount varies across states. Most state-level policies also provide road tax exemption for electric vehicles. This could provide relief for SRTUs as a large part of their expenditure is on state taxes, as will be discussed later in this report. The focus is also on implementation issues related to charging infrastructure. Capital subsidies on EV charging infrastructure are common across most states, but some have gone further to provide concessional land and preferential treatment for public charging stations to utilise renewable energy.

Indeed, electric mobility is a priority area for both the Central and State governments. The FAME policy has led to increased uptake of electric two-wheelers, three-wheelers, and buses. However, uptake has been well below intended levels, with only 10 percent of the allocated funds utilised till 2021.[12] There is still some consumer reluctance towards EVs due to the high capital costs and the lack of charging infrastructure. However, state governments have taken positively to electric buses as seen in a large number of tenders being issued by the SRTUs. The excitement around electric buses presents a great opportunity to drive an overall shift in the organised public bus transport in India. The next section highlights the future investments needed in the public bus system and explains how electric buses fit into the broader goal of creating a robust public transport system for the country.

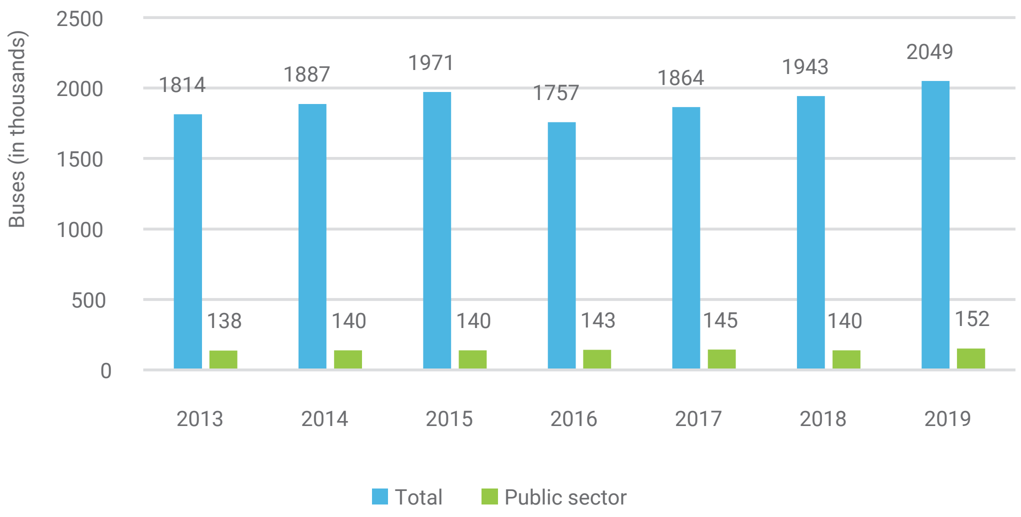
> Electric mobility is a priority area for both Central and State governments. FAME has led to increased uptake of electric two-wheelers, three-wheelers, and buses; though still below targets.

Financing the Transition to Electric Buses

The current thrust of policy support for electric buses is limited to the public sector. There is a need, therefore, to assess the investment in these vehicles in the broader context of creating a viable, organised public bus system. According to data from the Ministry of Road Transport and Highways (MoRTH), there were around 2 million total buses registered in 2019. Around 150,000 buses (7 percent of total) were owned and operated directly by the public sector through SRTUs. Among the 1.2 million privately owned buses, 70 percent had valid stage or contract carriage permits to carry out public services, while the rest were private. Most of the omnibuses were also engaged in private services, although the exact number is not clear from available government data. The privately owned buses involved in public services also largely operate outside the formal public transport system, unless they are run on a contract basis in partnership with the SRTUs.

This study is unable to identify an exact number for the buses being operated under such contracts, though the number differs widely across states. Some states such as West Bengal depend more heavily on contractual operations than others. Overall, the organised public bus services, particularly in urban areas, constitute only a small part of the total registered buses.

Figure 1: Registered Buses in India

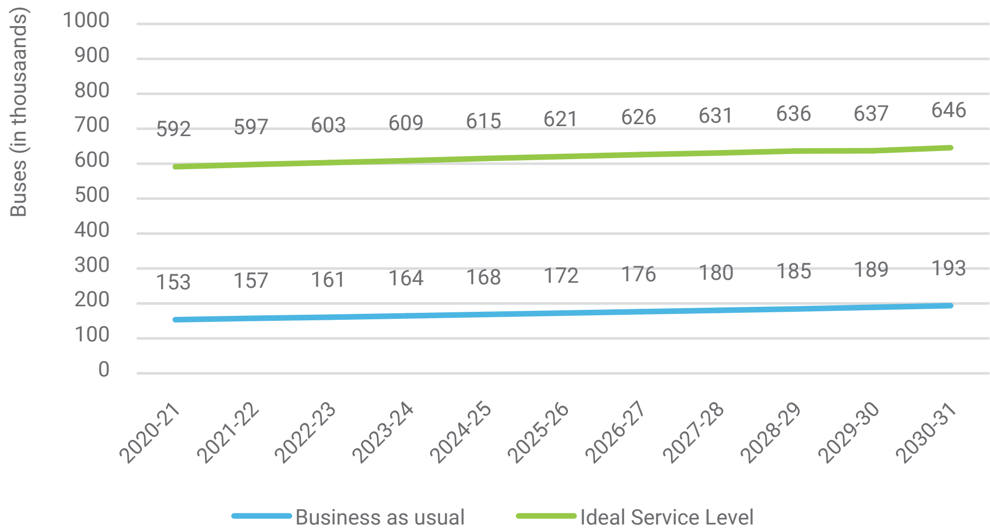


Source: MoRTH Yearbook, 2019-20

SRTU buses, the pillar of the organised public transport system, have a proliferation of 12 buses per 100,000 people across intra- and intercity operations.[13] According to benchmarks identified by the Ministry of Housing and Urban Affairs (MoHUA), Indian cities should have 60 or more buses per 100,000 people in the organised public transport system to achieve ideal service levels. For the rural areas, 40 buses per 100,000 people should be an acceptable benchmark. As per Census projections, India's population will reach 1.47 billion by 2030.[14] To achieve benchmark levels would require the organised bus fleet to expand to 646,000 buses by 2030. Around half of these buses would be needed for city bus services alone. Extrapolating from the decadal growth rate of the organised public bus fleet, the current levels of investment will be highly inadequate to achieve these benchmark levels.

The authors estimate that the country will need to add some 450,000 buses to the formal system by 2030. This will require SRTUs to directly purchase these buses or bring private operators on board through a significant scaling up of PPP arrangements. Thus, the current e-bus orders are a drop in the ocean given the colossal requirements of an overall shift. The future investments in electric buses must be embedded within the larger goal of ensuring a sustainable bus system.

Figure 2: Shortfall in Public Buses vs. Benchmark Levels



Source: Authors' projections, based on MoRTH data.

Capital Requirements and Financing Models

Going forward, the overarching goal should be to create a viable public bus transport system as a prerequisite for inclusive and environmentally sustainable growth. However, historically, investments in transport infrastructure have constituted less than one percent of GDP, and bus services have not been a priority area for public investment in transport. Private investment and PPP models have also been limited. Thus, a key consideration in the transition to e-buses is the capital requirement and the role of the public and private sectors to meet this need.

While it is difficult to make a generalised statement, given the diversity in the bus industry—on average, a 12-meter diesel bus with a rear-mounted engine and an automatic gearbox, costs around INR 4.5-5 million, and those with air-conditioning cost an additional INR 200,000. Smaller, 9-meter buses cost anywhere between INR 2.5-3.5 million depending on the fit and whether it is air-conditioned or not. Based on stakeholder feedback, the cost of the battery pack and power controller in an e-bus will add at least 50-60 percent to the cost if a single battery pack is considered. Currently, a 9m bus with a 175-kWh battery has an outright purchase price of around INR 12 million, whereas a 12m bus with a 250 kWh battery costs around INR 20 million, without subsidy.[15] Thus, the electrification of public bus services will impose a heavy additional capital burden.

The authors estimate that achieving the benchmark service levels for the organised city bus system through electric buses alone will require a cumulative capital investment of INR 19 trillion till 2030. This is assuming that 9m buses will continue to constitute 80 percent of all electric bus purchases (as seen in FAME-II) and that there will be a consistent decline in battery prices till 2025, as per a study by BloombergNEF (BNEF).[16] This represents three times the investment compared to a strategy focused on the purchase of ICE buses, including diesel, CNG, and LNG.

The present financing model prescribed in the FAME-II scheme aims to avoid the issue of higher upfront capital costs, by focusing on an OPEX-based model. This has the advantage of spreading out the additional costs over the lifecycle of the bus, rather than burden the public agencies with a high upfront purchase cost. Thus, the Total Cost of Ownership (TCO) of e-buses has become a more relevant metric. A 2021 study by the World Resources Institute (WRI) estimated the TCO to be INR 47.85/km and INR 65.9/km for a 12m e-bus with 125 kWh and 320 kWh battery pack, respectively. For a 9m e-bus, the cost was INR 54.58/km and INR 44.61/km for a battery pack of 180 kWh and 102 kWh. In all cases, the TCO for an e-bus was found to be slightly lower than the diesel buses when the FAME-II subsidies are considered. Without subsidy, the cost was much higher even with the fuel cost savings and lower maintenance cost of e-buses.

Pertinently, the TCO for EVs is extremely sensitive to several factors based on area and type of operations. The most critical factor is vehicle utilisation. Electric vehicles have much lower operational costs due to higher energy efficiency, the cheaper price of electricity, and lower maintenance costs due to fewer physical components. As a result, higher utilisation of an e-bus leads to more operational cost savings compared to a diesel bus. Thus, cities or routes with longer distances could be favourable for EVs in terms of their TCO. Second, capital cost is a significant influencing factor. There is still a lack of clarity regarding the ideal battery size for urban buses. As the battery size increases, the TCO becomes less favourable. However, in both these cases, there is a significant trade-off in terms of the charging requirements. The higher the utilisation, the more likely each bus will have to charge multiple times during the day. This will require additional charging infrastructure outside depots to allow opportunistic charging. Trip and route planning will also become more complicated, and most cities have so far utilised e-buses for the shorter routes to avoid this issue. Increased battery capacity can solve this problem to an extent but has negative cost implications.

Thus, there remains uncertainty regarding the actual cost of operating e-buses. This is reflected in the variation in the bids received as part of the FAME-II procurement process. A 2020 study by the International Association of Public Transport (UITP) analysed the tenders for 3,500 buses required under the FAME-II scheme. The average winning bid across the tenders was INR 63.3 and INR 69 per km for 9- and 12-meter buses, respectively. However, there was a large variation in the quotes: the highest quote was INR 79.8 per km, whereas the lowest quote was INR 52.2.[17] The quotes varied depending on several factors such as the assured km payment guaranteed by the public agency, payment for additional km, and penalties for non-performance. Further, there were differences in the provision of charging infrastructure. In some cases, the risk premium was also higher for the operators because the public agencies did not identify the depots which would be provided to the operating agency. Thus, in some cases the total expenditure with the operational cost-based financing model is actually higher than outright purchases since the operational cost savings are not getting passed on to the SRTUs due to the high-risk perception.

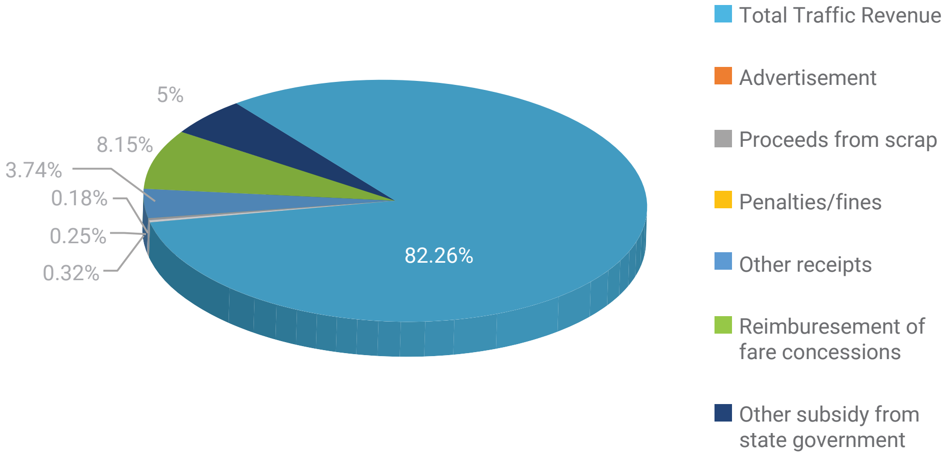
Even as the FAME subsidy might be able to galvanise the initial set of buses, eventually, it will have to become a market-driven industry. Therefore, the higher capital costs of e-buses cannot be ignored for too long and will likely become a critical factor. Even if this leasing-based model continues beyond the subsidy period, without the subsidy, the TCO for an e-bus is much higher than existing diesel buses. Buses running on alternative natural gas such as CNG and LNG, also have low operating costs while having a purchase cost that is only 20-30 percent higher than a diesel bus. From a purely financial perspective, therefore, these natural gas-based buses could yet be the best option. They may not be zero-emission, but they have lower emissions than diesel buses.

The silver lining has been the assumption that costs will fall eventually due to lower battery costs and economies of scale. As per estimates by BNEF, average prices of lithium-ion battery packs have fallen drastically from USD 1,200 per KwH in 2010 to USD 132 per KWH in 2021. However, the year-on-year decline slowed down significantly in the last year: between 2013 and 2018, the average year-on-year decline was 21 percent; between 2020 and 2021, the drop was a much lower 6 percent. The slowdown is likely to continue as commodity price rise does not abate and the shortage of raw materials such as electrolytes and lithium becomes more acute. It is also pertinent to consider that the global average battery pack price does not represent the state of technology in all parts of the world. The average is pulled down by the low cost of battery packs in China, where there are battery packs costing below 100 USD per kWh. The same BNEF study reports that battery packs in the US and Europe are 40 percent and 60 percent, respectively, more expensive on average. In India, battery manufacturing capacity remains limited and is imports-dependent, and as a result, the landed price in India can be as high as USD 201 per kWh.[18]

Financial Status of State Road Transport Undertakings

Under the present policy direction, SRTUs are key to operationalising electric buses in the short term. To understand their performance, it is important to first understand their financial-and economic status, which remains concerning. In 2016-17, SRTUs generated a total revenue of INR 558 billion, out of which, 82 percent of the receipts were traffic-based revenues, largely passenger tariffs. The contribution of non-tariff revenue sources is minimal, with the largest contribution coming from fare-concession reimbursements and state government subsidies. Since SRTUs lack the professional expertise to develop viable business models for generating revenues from existing infrastructure, they are unable to generate non-farebox revenues, such as advertisement and land development. Furthermore, the lack of accountability for financial losses is a major hindrance. In 2016-17 alone, a cumulative annual loss of INR 139.57 billion was recorded across 56 SRTUs.[9]

Figure 3: Revenue Break-up for SRTUs in India

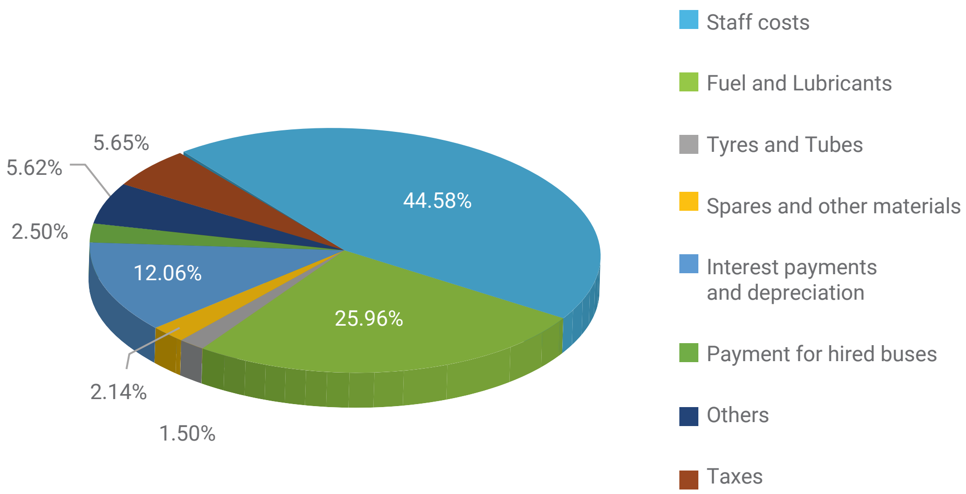


Source: Ministry of Road Transport and Highways, 2018 [9]

In the same time period, total expenditure was INR 697.77 billion, 25 percent higher than revenue. Staff costs made up the largest share of this, accounting for 44 percent at INR 311.09 billion. The average staff-to-buses ratio across SRTUs was 6.77 (including administration staff), and the total employees stood at 740,000 in 2016-17. Of the total costs, fuel accounted for 25 percent and interest-on-loan payments for 13 percent. This reflects the debt trap afflicting most SRTUs, wherein they are forced to take loans not only for capital expenditure but also to meet operational costs. Indeed, state and Central taxes accounted for a significant share of the costs (5.65 percent),[9] and during 2016-17, four SRTUs even turned a profit but went into losses due to the heavy tax burden.

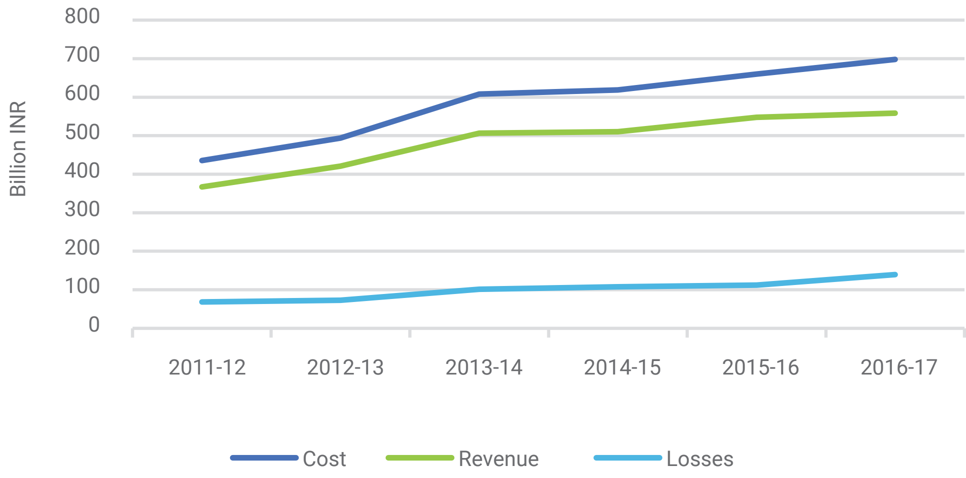
Over time, the expenditure of SRTU's have increased much faster than their revenues. In 2016-17, revenues increased by only 1.96 percent while costs increased by 5.72 percent. While limited losses have been reported since 2016-17, anecdotal evidence from across the country suggests that the trend continues. By 2020-21, even previously profitable SRTUs were running in losses due to the COVID-19 pandemic and rapidly increasing diesel prices. The Tamil Nadu SRTU has suffered a loss of over INR 300 billion over the past decade.[19] In Telangana, losses for the year 2020-21, totalled INR 26 billion.[20] In Maharashtra, the MSRTC, the largest SRTU by fleet size, sustained a loss of over INR 90 billion in 2020-21 and was further crippled by a worker's strike shortly after.[21]

Figure 4: Expenditure Break-up of SRTUs in India



Source: Ministry of Road Transport and Highways, 2018[9]

Figure 5: Revenues and Costs for SRTUs Over Time



Source: Ministry of Road Transport and Highways, 2017[9]

These losses are not only substantial but also systemic, stemming from the ingrained image of SRTUs as public goods providers and not business enterprise. Within the current policy pathway, this is arguably the single-largest impediment towards large-scale electrification of bus operations. Additionally, the OPEX-based financing model will add another layer of burden on the operational cost of SRTUs, exacerbating their financial dilemma. Thus, the ad-hoc purchase of electric buses through the FAME-II scheme can result in a lower overall investment in augmenting SRTU bus fleets.

Involving the Private Sector

Until a few decades ago, the passenger bus network was controlled entirely by SRTUs. However, given the declining financial condition of SRTUs, private operators were allowed into the system, leading to an exponential growth in private buses. In 2019, the private sector owned 1.2 million buses in India. This suggests that private bus operators may be more suited to handle large-scale bus electrification, compared to SRTUs.

While the current Central and state policies do not extend subsidies directly to the private sector, a significant portion of private service buses are engaged in fixed-route operations and have access to infrastructure that can be utilised for charging. These segments can be primed for electrification. For example, in 2019, there were 184,488 registered school buses, most of them owned by the private sector. These buses are appropriate for electrification, since they ply on fixed routes, have existing parking spaces, and their daily cycle includes long halts between journeys. Similarly, buses involved in airport services are also suitable for electrification. The government can roll out specific programs to introduce electric buses in these operations within the FAME-II scheme to boost electrification, and subsequently extend the existing subsidies to all private operators. Being less financially strained than SRTUs, private operators are less hindered by their financial position and have a longer time frame for assessing financial viability; thus, the future fuel cost savings from electric buses could be an attractive proposition for the private sector.

Private bus owners must be co-opted into the public bus system through PPP models, including electric buses. This will also improve the bus system in general. However, PPP arrangements in transport suffer from several issues. First, passenger transport is highly regulated, and private bus owners need to meet stringent regulatory criteria and go through extensive paperwork to obtain the right permits. Second, since there is no independent transport regulator, the government agency has all the power in the partnership and there is no easy redressal mechanism for the private players. Third, there is a patent lack of profitability, with fare limits set without many deliberations and no in-built fare revision mechanism. This translates into low revenue for the private players, and in the case of gross cost contracts, the payments are often delayed. However, some States also have successfully co-opted private buses into the formal public system. It is imperative to learn from the best practices of these states.

Policy Lessons

The investment in electric buses must be seen in light of the overall need to augment public transport and control the growth of private vehicles. Currently, electric buses cost thrice as much as their ICE counterparts, and the savings from operational costs are uncertain. Further, while the popularity of e-buses comes from zero tailpipe emissions, the lifecycle emissions are significant because of the dependence on coal for electricity generation in India. As per estimates from the Central Electricity Authority (CEA), the weighted average emission rate from the Indian electricity system was 0.80 tonnes of CO_2 per MWh of electricity generated.[22] Thus, investments in electric buses may not yield large emission savings till the electricity grid is largely powered by renewables or novel charging strategies are implemented so that electric buses utilise only renewable energy.

While the present FAME scheme has allowed some cities to opt for standalone electric bus order, the scale of uptake is not high enough to significantly augment the system. Going forward, the purchase of electric buses under the FAME scheme must be seen as one part of a broader investment plan, focused on achieving ideal service levels for public buses. To this end, investment in electric buses can be kept low at first, in favour of other low-emission alternatives such as CNG and LNG, and scaled up gradually as the grid switches to renewables and the cost of batteries decline. Moreover, the present policy focus of providing subsidies for only public agencies needs to be reconsidered, since placing a higher cost burden on these agencies without improving their finances can hinder much-needed investments in other parts of the fleet.

Large-scale electrification of buses will depend on greater involvement of the private sector through a re-oriented policy approach. The following policy lessons have been derived from the current experience across states.

Develop state-specific roadmap for electric bus adoption: All states should have a clear roadmap for achieving the highest service levels for their public bus system, keeping in mind the required investments. The states that are financially strained will require major capital investments; they must view any improvement to the bus fleet as positive, electric or not. The better-performing states can focus more on EVs, since they need lesser investments to reach an acceptable service level.

While the FAME-II subsidies can be utilised for electric bus purchases, SRTUs must also need to consider cheaper technologies as part of their roadmap. CNG and LNG are promising alternatives, since they have a purchase cost only 20-30 percent higher than diesel buses, with lower emissions of greenhouse gases and air pollutants. Moreover, operational costs of natural gas alternatives are much lower than diesel. They can thus be the ideal bridge technology between existing diesel buses and future cost-effective zero-emission technologies, especially in states struggling to improve their public bus system. To this end, the Central government must continue large-scale procurement of diesel, CNG, and LNG buses under existing schemes such as the JNNURM, Smart Cities Mission, and AMRUT. These should run in tandem with the FAME scheme but should not focus solely on procuring e-buses. In the long term, once e-bus costs are lowered, the sole focus can shift to this technology or other low-emission technologies that are developed in the interim.

Improve financial position of SRTUs: State governments must prioritise SRTUs as an essential public goods provider. SRTUs pay multiple taxes to Central, state, and municipal corporations including property tax, value-added tax, and motor vehicle-related taxes. Governments at all levels should consider long-term tax exemptions for these entities, as has already been done for many metro operators such as the Delhi Metro Rail Corporation. Efforts should also be made to reduce the staff costs of SRTUs. This will require the rationalisation of existing personnel assigned to buses, a task currently made difficult by the strength of bus unions in India. To address the issue, alternate jobs can be provided for existing SRTU staff in other departments. Further, SRTUs must be empowered to increase their non-tariff revenues and encouraged to collaborate with other government agencies, to bring on professional expertise that can help them leverage existing land resources and improve revenues from advertisement. State governments must mandate all SRTUs to develop long-term plans for improving their financial positions, and demand accountability from SRTU operators in terms of meeting financial targets. Concessions can be made contingent upon SRTUs achieving certain financial targets or implement revenue-augmenting schemes. FAME subsidies can also be linked to the improvement of the financial performance of SRTUs.

Reduce perceived risk for potential FAME-II contractors: There is a significant difference in prices quoted by operators in the FAME-II bids, due to differences in perceived risk across cities. One key concern has been the ability of the cash-strapped SRTUs to initiate timely payments. State- and national-level agencies should establish mechanisms to ensure payment to operators in case SRTUs fail to fulfil their obligations—in the form of bank guarantees or guarantee on the loans taken by operators to purchase buses. Some cities also pass on the burden of installing charging infrastructure to operators. DHI should mandate that all civil and electrical infrastructure-related works should be the prerogative of contracting authorities, since they are much better placed than bus operators to implement this. Moreover, considering that the infrastructure has a much longer life than the duration of the contract, operators tend to inflate their quoted prices.

Since the capacity of a city to implement infrastructure for e-buses influences the bid price, DHI should identify the cities best suited for electric buses and give them preference when offering subsidies. The selection criterion can include the present state of city bus service and the city's expertise in implementing the required charging infrastructure for e-buses. Once more buses are inducted to create a robust public bus system, e-buses can complement the existing network. This will also incentivise other cities to improve their bus systems to eventually avail of the subsidies.

Alternate financing models for e-buses: Some SRTUs may prefer an outright purchase model against an OPEX model, which gives them more freedom to operate the buses while reducing their dependence on external operators. Such a model is especially relevant for financially healthy SRTUs and can help them develop the capacity for planning electric bus infrastructure and operations, to remain profitable once the subsidies are scaled down. State and national banks can support the model by providing loans at a discounted rate to SRTUs for e-bus purchases. Furthermore, operators charge more in the OPEX models, which leads to higher project costs even if the upfront costs are lower, the "outright purchase" model can be much more cost-effective in the long run.

Increased private sector participation: Private sector participation should be encouraged to drive e-bus adoption and augment the overall public bus system. Two broad strategies can help: (i) The FAME-II subsidy should be extended to private operators, especially for buses involved in easy-to-electrify operations, such as school buses and airport operations. Separate allocation can be made for private operators within the overall FAME budget; and (ii) The lack of profitability from bus operations is a major hindrance to inducting private buses into the organised public bus system. SRTUs should have a periodical fare revision mechanism to account for the increase in fuel prices and staff costs. This will allow for more competitive tariffs and encourage private buses to enter the organised bus system on a contractual basis. Alternative models involving some level of control over farebox revenues to private operators must be implemented for specific operations, such as creating an alternate premium bus service alongside the broader public bus system.

Channelling green funds to buses: Public and private investors in India and abroad are increasingly looking to finance green projects. Hitherto, most of this funding in the transport sector has gone to metros. Buses, especially electric buses, must be established as a potential avenue for this investment. Currently, the *lack of* *profitability* and *inadequate professional capacity* in SRTUs are the major barriers to attracting global green capital to the bus system. Establishing the value proposition for investment in buses will help mobilise and attract domestic and international capital. The Central government must actively advocate for buses as a channel of investment, as it has done for metros.

There is a strong case to be made for setting up a National Transport Development Finance Corporation, along the lines of some state governments, such as Tamil Nadu and Kerala. This body can disburse funds to the SRTUs and help in purchasing buses as well as paying for operational costs.

Large-scale electrification of buses will depend on greater involvement of the private sector through a re-oriented policy approach.

Impact on the Manufacturing Ecosystem

The automobile manufacturing sector in India has grown rapidly since the delicensing and opening up of FDI in 1991. Today, India has the fifth-largest automobile manufacturing market in the world.[23] The industry contributes directly to 7.1 percent of the GDP and 22 percent of the manufacturing GDP.[24] Data from the Society of Automobile Manufactures (SIAM) shows that vehicle production in India stood at 22.6 million units in FY21. Two-wheelers accounted for 80 percent of the production, making India the largest manufacturer for two-wheelers in the world.

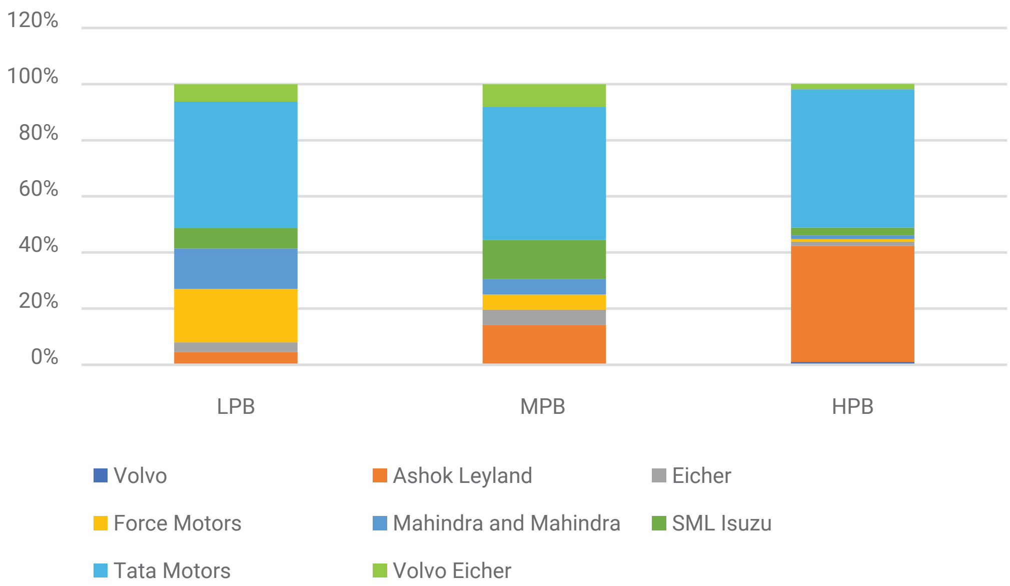
The switch to electric mobility has created a new paradigm in the manufacturing ecosystem. The question to be addressed is how changing the raw material and component requirements for electric vehicles can alter the manufacturing ecosystem and its contribution to imports, net value-added, and employment. Given the similarity in components across electric vehicles, it is difficult to assess electric buses without focusing on the changes in the whole ecosystem. This section assesses the impact of the transition to electric mobility on the manufacturing ecosystem holistically, with a focus on e-buses. It must be noted that the changes noted below will be influenced by the complete e-mobility transition, of which buses are a significant component.

Evolution of Electric Bus Manufacturers

India is the second-largest manufacturer of buses and coaches in the world.[25] Figure 7 shows the market share of traditional manufacturers in India since 2012. Across bus sizes, Tata Motors has a significant share of the market, maintaining approximately 45 percent shares in all bus segments. The other major manufacturer for large buses is Ashok Leyland. In the smaller bus segments, Force Motors and SML Isuzu have a decent market share.

In recent years, many traditional manufacturers have started making the switch to electric buses. Both Tata Motors and Ashok Leyland have won large contracts from the FAME-II rollout (See Figure 8) and have altered their organisation structures and investment to expand their electric vehicle-production capacities. Tata Motors has incorporated a new subsidiary for the manufacture of electric vehicles, with an initial capital outlay of approximately INR 7 billion. Ashok Leyland has transferred its e-mobility to "switch mobility," for a consideration of INR 2.4 billion.

Figure 6: Market Share for ICE Buses, by Manufacturer

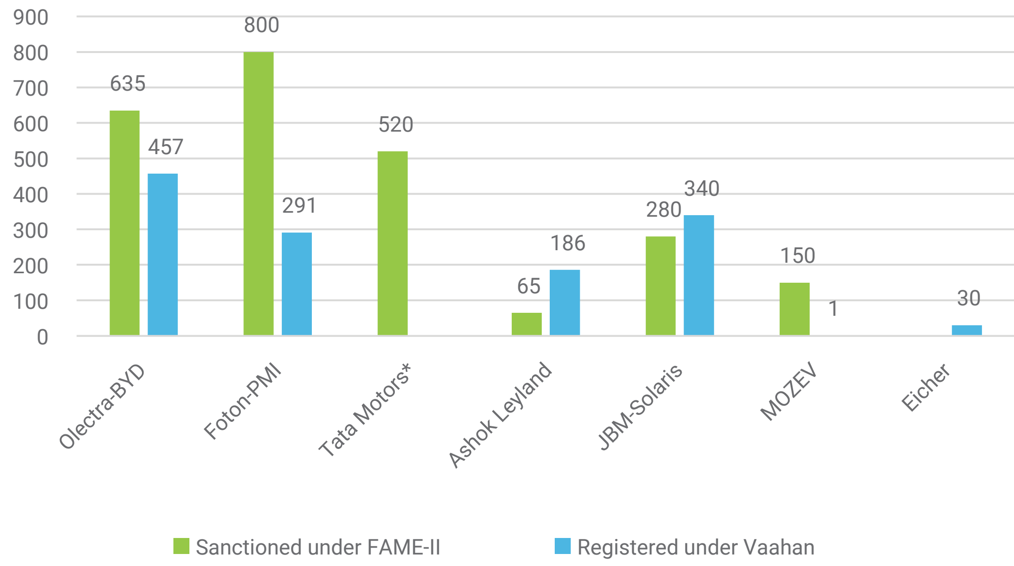


LPB: Light Passenger Bus; MPB: Medium Passenger Bus; HPB: Heavy Passenger Bus
Source: Vahan Dashboard.[d]

d Excludes omni buses involved in private operations.

The opportunities provided by electric buses have encouraged many new players to enter the space, and joint ventures (JV) have been drafted between Indian and foreign firms, with the former relying on the latter for design engineering. The most prominent is Olectra-BYD, a joint venture between the Indian company Olectra Greentech and the Chinese bus-manufacturing behemoth Build Your Dreams (BYD). The company has been successful in securing tenders under the FAME-II policies and has already delivered 400 e-buses and secured tenders for more. Olectra-BYD has one production facility in Hyderabad capable of producing 1,000 buses per year, with another 3,000-unit plant coming up soon. The other new entrant is the JV between the Indian MI Electro Mobility Solutions (70 percent ownership) and the Chinese Beiqi Foton Motor Company (Foton). Foton-PMI has secured an order to supply 700 e-buses to Uttar Pradesh. The venture has one manufacturing plant in Haryana, with plans for another in Pune. It claims that 55 percent of its products are localised and has plans to set up an in-house battery manufacturing plant in Haryana next year. Jay Bharat Maruti (JBM) has also recently entered into a partnership with the Polish company Polaris, to produce e-buses. JBM is originally among the largest auto component manufacturers in India, especially for Maruti Suzuki.

Figure 7: e-Buses Tendered under FAME (till 2020) and e-Buses Registered under Vahan, by Manufacturer



Source: UITP (2020)12 and Vahan Dashboard.

** Data for Tata Motors was not available in the Vahan database; stakeholder consultations suggest around 600 e-buses have been deployed.*

The proliferation of newer manufacturing companies has been driven by the off-the-shelf nature of electric vehicle components. Discussions with stakeholders suggest that manufacturers are currently importing most components. The legacy manufacturers have managed to alter their existing bus platforms to adapt to the changes needed for electric buses, the most important of which has been the re-orientation of the bus structure to account for the extra weight and space requirements for battery packs. Newer firms have also managed to build dedicated platforms for assembling e-buses. However, the components related to the battery pack, motor components, electronic components, and wiring harnesses are almost entirely import-dependent. This new paradigm has significant implications for the extensive automobile component industry and the value added to and job generation from the automobile industry as a whole.

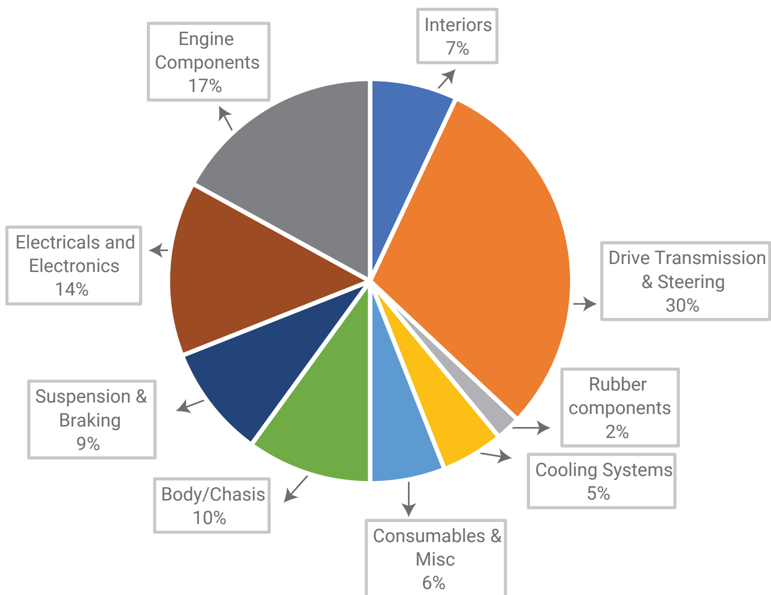
Impact on the Auto Component Industry

Policymakers view indigenous component manufacturing as a critical step to maximise the economic benefits from the electric mobility transition. The level of indigenisation will have major implications on the net value added, imports, and jobs generated from the automobile ecosystem. The Automobile Mission Plan 2016-26 aims to increase the share of the sector in GDP to 12 percent and generate an additional 65 million jobs. The electric vehicle transition will have a significant impact on meeting these targets. The local manufacturing of traditional internal combustion engines (ICE) and transmission systems have led to the creation of a large and vibrant components industry. According to the Automotive Component Manufacturers Association (ACMA), the industry contributed 2.3 percent to GDP and employed approximately five million people.[26] While some component players such as JBM have made the full shift to e-buses, others are fearful that a large, unplanned shift to electric vehicles across the board could devastate the component industry. There are two broad questions to be addressed: i) How much will the demand for components change in the transition to EVs? ii) How much of the additive supply chain for EVs can be indigenised?

An EV has less than a tenth of the moving parts of an internal combustion engine. Thus, as EV manufacturing increases, the component demand per vehicle will be lower. However, motor vehicle sales are expected to increase significantly in the future. The demand for motorised transport in India is still low, with vehicle penetrations at around 32 vehicles per 1,000 people.[27] As per capita income rises, so will the demand for motorised transport, driving higher sales. Between FY16 and FY20, domestic automobile production increased at a CAGR of 2.36 percent despite the overall slowdown in the economy.[28] Extrapolating from this, annual production could be around 30 million by 2030. In reality, this is likely to be much higher if the vision of the National Automotive Plan is achieved, and automobile manufacturers expect that sales could increase three times to around 60 million by 2026.[29] Of these sales, 30 percent can be expected to be EVs by 2030 in the most optimistic scenario. This still leaves a large demand for ICE vehicles and their associated components in the next decade. Thereafter, as EVs become more competitive, the demand for ICE components could come down drastically.

India has substantial manufacturing expertise and facilities to make the chassis and body components required for not just fully built buses but also the body-on-frame type of mid-floor buses. Engine and transmission parts have also been indigenised to a large extent. While newer automatic transmission systems still use some degree of imported components, steering components rely heavily on imports, specifically for the controllers and the steering shafts. The electrical components, which make up only a small proportion of the ICE buses, are also largely imported. Thus, there is already a significant import dependence for auto components in India. In 2018-19, overall auto component imports stood at US$17.6 billion, with drive transmission and steering (30 percent) with the highest share, followed by engine components (17 percent), and electricals and electronics (14 percent) (See Figure 9).

Figure 8: Distribution of Auto-Component Imports in India (2018-19)



Source: Automotive Component Manufacturers Association (ACMA).

Going forward, the value-added and import dependency of the component industry will be influenced significantly by the ability to indigenise the production of EV components. Specifically for electric buses, the battery pack makes up 40-45 percent of the total asset value. This is followed by the chassis and other body parts (30-35 percent), the powertrain (20-25 percent), and electronic systems (five to seven percent).[30] This setup differs significantly from ICE buses, with the share of electrical components being much higher in e-buses. Presently, India has limited production capacity for most of the critical EV parts. Almost all of the critical components such as the motor, vehicle control unit, and other electrical systems are being imported (See Table 4). For wiring harnesses and connectors, India has a significant capacity to produce low-voltage wiring harnesses. However, these are inadequate for the high output EVs, especially buses. Production of high-voltage harnesses is limited and most of it is already used in the power sector. In the case of batteries as well, Indian firms currently only assemble the battery packs, and the battery cells and other components are completely import-dependent.

Table 4: Production Capacity in India for Key EV Components

Critical component	Net Localisation	Remarks
Batteries	10-15%	• Battery pack assembly capacity has been developing • Some capacity for thermal management systems
Traction motor and controller	0%	• Possible domestic capacity for rotor, stator, bearings, brackets, and housing • Domestic components have low power capability
Wiring harness and connector	15-20% (High voltage)	• Competing demand from the power sector leads to less availability, despite production capacity
Vehicle control unit	0-5%	
DC-DC converter	0-10%	• Some capacity for software development and testing
On-board charger	0-5%	
Electric safety devices	30-35%	• Limited capacity for producing printed circuit boards, passive components, and fuse breakers and contactors
Electric compressor	0%	

Critical component	Net Localisation	Remarks
Transmission	70-80%	• Extensive capacity from existing ICE vehicles • With increasing automatic transmission systems for EVs, imports could increase
Body and chassis	85-90%	• Extensive capacity from existing ICE vehicles • Might require some changes for light-weighting, especially for buses • This could lead to increased use of lighter materials such as aluminium
Tyres	90-95%	

Source: Compiled from SIAM, ACMA, Nomura Research Institute,[31] and stakeholder consultations.

Thus, the existing component industry will have to adapt significantly to become a relevant supplier in the EV space. However, the extent of changes will differ based on the type of component supplier. For the body, chassis and, to some extent, transmissions, the existing TIER-1 and TIER-2 manufacturers can make the switch to producing components for EVs relatively easily. However, going forward, they must find innovative ways for light-weighting these components to better compensate for the additional battery weight, especially in buses that have a large battery pack. For the manufacturers involved in making engine parts such as pistons, engine valves, fuel pumps, fuel ignition systems, and carburettors, the transition will be much more difficult. There is a clear consensus among the OEMs and component suppliers that requirements for producing EV motors and electrical components require very different equipment as well as technical knowledge. Design knowledge for these components does not currently exist in India and will have to be developed, which will require significant R&D and technology transfer. For TIER-3 suppliers, the change also might be achievable, given that these are mostly suppliers of metal or plastics, the requirements for which may not change much in the future.

The auto component industry has also witnessed several changes in the recent past, which could have a bearing on their ability to adapt to the newer changes. Some of the major changes are stated below.

- There has been increased concentration and acquisition of auto component suppliers in India. According to some sources, the number of auto parts suppliers in India has reduced from 30,000 in 1990 to around 3,000 at present.[32] This has also led to modularisation, where suppliers no longer just provide one component but a plethora of different components. Consequently, suppliers now have access to a higher level of finances and knowledge, which could be crucial in terms of their ability to pivot to other products in the future.

- Newer players have also started to enter into this space, especially focused on producing electrical components relevant for EVs.

- Component suppliers have started to pivot and enter into the manufacturing space. The biggest example of this is JBM successfully starting e-bus production.

- The component requirement in adjacent industries is likely to grow rapidly, driven by the impetus on indigenous production. Sectors such as aerospace, defence, and agriculture could provide an alternate source of demand for component suppliers in the future. Defence and aerospace are heavily dependent on imports at present, but there is potential to produce these components locally, especially as import duties on these products are likely to be hiked in the future. Increased mechanisation of agriculture could also create opportunities for the component industry as demand for sub-components such as threshers, rotavators, and tractor parts increases.

Industrial Policies for Manufacturing

The Central government has also taken active steps to accelerate the indigenisation of the EV manufacturing ecosystem for all vehicle segments. The first major step was the Phased Manufacturing Programme (PMP) under FAME-II. The PMP adopted a two-pronged mandate-based strategy to push OEMs to adopt indigenous components. The first step was a timeline-based hike in Basic Customs Duty (BCD). For buses, the BCD on completely built units (CBUs) was increased from 25 to 40 percent in 2020. Similar hikes were also implemented for semi-knocked down and completely knocked-down units. However, the envisaged component-wise increase in BCD for critical EV parts has been delayed because of the COVID-19 pandemic. For example, the proposed hikes for electric throttles and electric motors were extended to April 2021 from 2020.

The second part of the PMP was a mandate to indigenise the use of certain components for vehicle models to be eligible for the FAME-II subsidy. The targets were very aggressive: for buses, almost all components were mandated to be produced indigenously by April 2021 to avail of the subsidy. However, since indigenous components have been defined as "domestically manufactured/ assembled," products that are assembled here but with low net localisation can also be counted in this. All these efforts have been delayed due to the nascent nature of the EV component industry and resistance from the automobile industry. The relaxations have been a significant relief for OEMs, since sourcing components locally can be a costly endeavour. Especially during COVID-19, this would been an added burden and exacerbated a situation already affected by a slowdown in sales and increase in costs due to the implementation of BS-VI norms and the global increase in input prices.

The second step has been the announcement of the "Production Linked Incentive (PLI) Scheme for Automobile and Auto Components" in September 2021. This scheme aims to provide financial incentives to certain OEMs and component manufacturers involved in producing advanced automotive technology needed for EVs and fuel cell vehicles. The plan is to provide incentives worth INR 259.38 billion till FY27. However, the scheme lays strict eligibility conditions for firms to avail of the incentive. Existing component suppliers need to have a domestic investment of INR 300 million before 31 March 2023, increasing to INR 25 billion by 21 March 21 2027. New OEMs and component suppliers can also avail of the scheme but with a higher level of domestic investment. The scheme does not specify the nature of these investments, and the incentive is a percentage of the determined sales value,[e] ranging from 13 to 16 percent for OEMs and from eight to 11 percent for component suppliers. However, a minimum of 50 percent domestic value addition is mandated to be eligible for the incentives, and this percentage must be further scaled up under a phased manufacturing programme. The actual technologies eligible under this scheme are to be decided by the Ministry of Heavy Industries (MHI). The broad definition of advanced automotive technologies could also divert from a clear-cut focus on critical EV components. The difficult entry criteria also favour larger manufacturers

e Determined sales value is defined as: (Eligible Sales Value for a particular year) minus (Eligible Sales Segment for Base year (FY19)).

and preclude the participation of MSMEs and start-ups in this space.

The Union government is focused on indigenising the whole supply chain regardless of the present state of technology, since these schemes can bring about transformative changes in the manufacturing and component industries. There is no effort to assess the relative cost and quality of imports versus local production, with the government is working under the assumption that as manufacturing expands and economies of scale are achieved, Indian products can achieve the same standards as their foreign competitors and become cost-competitive with their ICE counterparts. There is also a belief that Indian suppliers will be better placed to create products suited to Indian conditions. Further, the value addition or net localisation specified in all the policies only accounts for the labour, raw material, components and other material costs embodied in a product. The present policies do not cover the issue of technology acquisition, the royalty payments, or intellectual property aspects. As a result, lot of the technology transfer to India is happening through foreign firms setting up assembling plants in India or through JVs with Indian firms. This is especially relevant for OEMs, since the electric component manufacturing remains nascent and it is not yet clear whether the same trend will be followed. The ownership of technology has significant implications in terms of the ability of local firms to develop design capacities to utilise components and raw materials that may be more suited to India, both in terms of cost and availability.

State governments have also included supply-side interventions as a key part of their EV policies (See Table 5). Tamil Nadu, Andhra Pradesh, and Telangana, in particular, have announced significant supply-side interventions. These states see the transition to electric mobility as an opportunity to redefine the traditional auto cluster, by attracting newer manufacturers and component suppliers. The focus is on maximising manufacturing value addition and jobs from the EV transitions. Some of the notable interventions are described below:[33]

- Capital subsidies are being offered to vehicle manufacturers, component suppliers, charging infrastructure, and battery manufacturers. Some states also have differentiated incentives based on the size of the enterprise, to promote both MSMEs and larger manufacturers. Karnataka provides a subsidy of 25 percent to all MSME auto manufacturers, but the subsidies for larger companies are restricted to battery assembly and charging infrastructure manufacturing. Tamil Nadu offers capital subsidies only for intermediate products used to manufacture EVs and charging infrastructure, which could provide a strong boost to the component industry. Telangana offers a capital subsidy up to 20 percent up to INR 300 million, while Kerala offers a 20 percent incentive only to OEMs.

- States are providing reimbursement on state goods and service tax (GST) collections as well as interest subsidies on loans. The GST reimbursements range from 60 to 100 percent usually over five to 10 years. Some states such as Maharashtra, Andhra Pradesh, and Karnataka provide higher reimbursement to MSMEs, compared to the larger enterprises.

- Some states have deployed land development incentives to reduce the high upfront land costs and to create industrial clusters in certain less developed regions. The incentives consist of direct subsidies on land cost, fee waivers, and exemptions from stamp duty and other registration fees. Tamil Nadu, Uttar Pradesh, and Uttarakhand offer direct subsidies on land ranging from 15-50 percent. Tamil Nadu has a scale-based system where higher subsidies are provided for manufacturing facilities that are set up in less developed districts. The focus on industrial clusters can benefit the component industry, since there is equal focus on providing subsidies for the OEMs and the component suppliers. For example, Andhra Pradesh promotes integrated mega-projects by offering land at the same concessional rate to component suppliers and OEMs.

Thus, both national and state policies are in place to accelerate the manufacturing ecosystem for EVs. There are some notable points of departure between the policies at the two levels. **First**, state policies provide upfront incentives, whereas national policies provide incentives based on actual sales. **Second**, the eligibility criteria for national policies will only allow larger players to avail of the incentives; states are focused on MSMEs as well. **Third**, state policies have no specific criteria for domestic value addition, and their objective is to attract as many investors as possible regardless of the nature of their supply chains. It is still too early to judge the effectiveness of these policies.

The supply side focus of state policies could also have significant implications on shifting auto clusters. The traditional automobile clusters in India have been in Maharashtra and Tamil Nadu, while in the recent past, Haryana, Gujarat and Karnataka have also managed to attract OEMs. This has created strong backward

Table 5: Supply-Side Incentives, by State

	Capital subsidy	Tax exemptions and interest subsidies	Land development incentives	Concession on Infrastructure
Andhra Pradesh	Green	Green	Green	Green
Bihar	Red	Green	Green	Red
Delhi	Red	Red	Red	Red
Karnataka	Green	Green	Green	Green
Madhya Pradesh	Red	Red	Red	Red
Maharashtra	Red	Green	Red	Green
Punjab	Red	Green	Red	Green
Tamil Nadu	Green	Green	Green	Green
Telangana	Green	Green	Green	Green
Uttar Pradesh	Red	Red	Green	Red
Uttarakhand	Green	Green	Green	Green
West Bengal	Red	Red	Red	Red
Gujarat	Red	Red	Red	Red
Kerala	Red	Red	Green	Red
Meghalaya	Red	Red	Red	Red

Source: World Resources Institute India, 2021.[34]

and forward linkages and led to the concentration of manufacturing with large economies of scale. The electric mobility transition has the potential to alter this, because the barriers to entry for EV manufacturers is lower than the ICE segment. There has already been a marked increase in the number of new startups involved in the manufacture of electric two wheelers, with many choosing the base their operations outside the traditional clusters.

Further, the EV value chain will invite participation from new players, many without any previous experience in vehicle manufacturing. Already, companies from other industries have pivoted to producing electric vehicles, components, or battery manufacturing and charging systems.[34] However, in addition to incentives, the success of clustering policies will depend on multiple factors.[35] Literature on clustering policies suggest that the success of an industrial cluster depends on attracting anchor firms, which are crucial to creating the demand needed to foster a large ecosystem that can lead to economies of scale. This requires action from local governments to provide enabling infrastructure such as roads, ports, and electricity. Further, institutional changes are needed—in particular, rationalising taxes and reducing red tape. Without a combination of these measures, efforts at newer clusters may result in sub-optimal levels of production, eventually translating into higher costs in the long run.

Trade Implications

While India's strategy has been one of complete indigenisation, it is important to consider the tradeoff between domestic manufacturing and imports. This section summarises the findings on this topic based on the responses from stakeholders.

As mentioned earlier, several OEMs have already developed their electric bus manufacturing capacity in India. While existing OEMs have established fully owned subsidiaries, most new entrants consist of joint ventures with foreign companies. So far, the most significant driver has been domestic demand, but there are ambitions of tapping into the export market as well. As per SIAM data, OEMs exported 4.1 million ICE vehicles in FY21, but bus exports made up a minimal share. As electric buses emerge, Indian OEMs believe that the existing technological prowess and the low cost of manpower could lead to India's buses competing with Chinese manufacturers for the export market. However, the nature of technology acquisition in the case of electric buses could pose a challenge to utilising India's traditional competitive advantages. Traditionally, Indian manufacturers have been able to compete in the global markets because of a focus on frugal engineering and collaborative efforts with component suppliers to develop low-cost supply chains. The OEMs entering the space, particularly the newer players, are often dependent on their foreign partners for their designs and technology. Thus, it may be difficult to emulate the traditional model in case of electric buses, if there isn't a clear focus on developing in-house design engineering capacity. Indeed, electric vehicle manufacturing is less labour intensive, and a lower cost of human capital may not be sufficient for OEMs to reduce costs and provide competitive prices for the global market.

The situation is more complicated when it comes to auto-components. The Indian auto component industry has grown not only to fulfil domestic demand but also as a strong exporter. Since 2018-19, components exports have grown at a CAGR of 10.9 percent, reaching US$15.6 billion in 2018-19. Drive transmission and engine components alone accounted for 55 percent of the total exports. Location-wise, North America and Europe accounted for around 66 percent of the exports. However, the share of Indian imports in most countries continues to be low, for example in the US and Germany, the share of Indian products in total component imports was only 1.6 percent and 0.9 percent, respectively.

The key driver for the growth has been the relatively lower cost of Indian components in developed economies, due to affordable manpower and frugal innovations. However, India continues to import a large share of components. China accounts for the highest share in imports (24 percent), followed by Germany (14 percent) and South Korea (10 percent). The need for high-tech parts required for compliance with new emission norms, automated steering systems, an increased role of electrical systems has led to an increase in imports due to the lack of capacity in India. Thus, India does not currently have the domestic capacity for producing critical EV components, which is likely to further increase imports, particularly from China. Going forward, government policy must account for the trade-offs associated with import substitution and the growth of EV manufacturing. Some improvements that Indian component suppliers will need to make, to compete with the best global products are: i) faster turnaround times ii) automating the supply chain and improving product consistency iii) specific understanding of customer requirements and high level of customisation and iv) adapting to fulfil aftermarket demand.

The Centre aims to reach 100 percent localisation, and is thus keen on increasing custom duties on EV components. In the short term, this may have a negative knock-on effect by increasing the cost of EVs and leading to the uptake of sub-optimal products. Further, this could create compatibility issues as many OEMs already have a good understanding of foreign manufacturers. Thus, the scaling up of import duties must be done in a measured manner. At the same time, industrial policy should focus on creating enabling conditions for Indian component makers to develop more competitive products. In particular, the efficiency of the logistics sector must be improved: logistic costs in India continue to be three to four times higher than developed economies, and there is a need to remove supply chain blockages and improve multi-modal connectivity. Additionally, competitive procurement of certain raw materials, particularly steel, must be ensured, and innovation and R&D accelerated to increase indigenous design engineering. This will be essential to developing inexpensive products and utilising India's competitive advantages in terms of raw materials. This will help India develop its USP in the EV component market globally, while also satisfying domestic demand.

Battery Manufacturing

India currently has some capacity for assembling battery packs, but is completely import-dependent for battery cells and other pack components. According to the Ministry of Commerce and Industry, India imported 71,392 battery cells and primary batteries worth INR 1.72 billion in FY21. This represented a 17 percent increase from the previous year, indicating a rapid increase in battery demand. If the import dependency persists, battery cell import alone could more than triple by 2025.

Thus, there is a lot of focus on indigenising the value chain for lithium-ion batteries. However, establishing battery manufacturing facilities requires large-scale capital mobilisation. Taking an optimistic assumption that India will acquire 10,000 electric buses annually by 2030, it will need an annual manufacturing capacity of 5 gigawatt hours (GWH) for buses alone. If one adds passenger cars, two-wheelers, and even short-distance intra-urban commercial vehicles to the mix, India would need at least 50-60 GWH of battery manufacturing capacity. This would require an investment of over INR 11 trillion in battery manufacturing, assuming the cost of building a state-of-the-art battery mega factory to be around US$5 billion for a 20 GWH capacity plant, based on examples from the US. The actual costs in India could differ depending on the economies scale that can be achieved and the level of control over the supply chain for raw materials.

To this end, the Central government announced the "National Programme on Advanced Chemistry Cell (ACC) Battery Storage" in June 2021. The scheme aims to provide sales-based incentives of INR 181 billion till 2029 to build 50 GWH of ACC manufacturing capacity and 5 GWH capacity for high-performance niche ACC technologies. The incentives will only be for battery cell manufacturers, not battery pack manufacturers. To be eligible, firms must commit to building a minimum 5GWH capacity plant with a maximum 20 GWH capacity allocated to a single firm, as well as incur the mandatory investment of INR 2.2 billion/GWH and have their plants operational by 2024. The scheme mandates an initial domestic value addition of minimum 25 percent, which has to be scaled up to a whopping 60 percent in the next five years. These conditions will have significant implications on the technologies adopted by the firms as well as their costs. The actual incentive will also be calculated as a proportion of the actual sales and the domestic value-added in a particular period.[f] The scheme is also technology agnostic, allowing any battery cell chemistry to avail of the subsidy.

Regardless of the increase in battery manufacturing capacity, India is likely to find itself on the wrong end of the raw material supply chain. Mineral availability, particularly lithium, will be a long-term problem. While there are potential future non-lithium-based energy storage technologies in development, they are far away from commercial use. Lithium supply is presently concentrated in certain pockets. The largest proven lithium deposits are in Chile (9 million MT), followed by Australia (4.7 million MT), Argentina (1.9 million MT), and China (1.5 million MT).[36] However, the lithium content and the state of mining technology vary significantly in these countries. Global production of lithium reduced by five percent between 2019 and 2020. This can be largely attributed to the scaling down of EV subsidies in China. Australia accounted for 48 percent of lithium production, followed by Chile (21 percent), China (17 percent), and Argentina (7.5 percent).

Table 6: Global Lithium Reserves and Production

Country	Mine production		Reserves (in tons)
	2019	2020	
USA	N/A	N/A	750,000
Bolivia	N/A	N/A	21,000,000*
Australia	45,000	40,000	4,700,000
Chile	19,300	18,000	9,200,000
China	10,800	14,000	1,500,000
Argentina	6,300	6,200	1,900,000
Brazil	2,400	1,900	95,000
Zimbabwe	1,200	1,200	220,000
Portugal	900	900	60,000
Canada	200	0	530,000
Other countries	0	0	2,100,000
World total	86,000	82,000	42,000,000

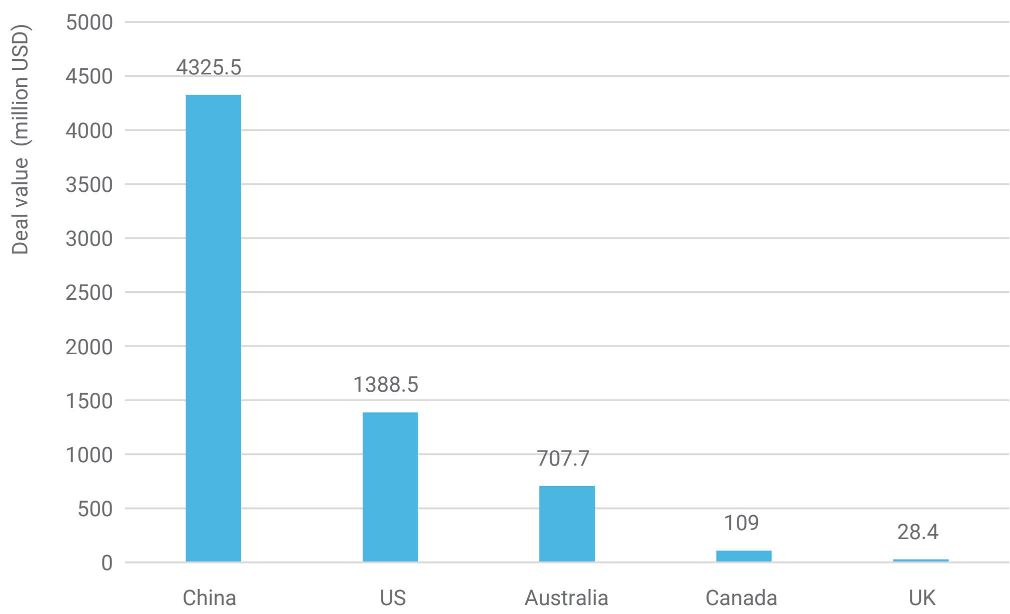
Source: United States Geological Service.[37]

**Approximate value based on multiple sources.*

f Total subsidy: Applicable subsidy amount per kilowatt hour x Percentage of value addition achieved during the period x Actual sale of Advanced Chemistry Cells.

Despite the slowdown, China significantly increased its domestic production by 33 percent between 2019 and 2020. This is a result of concerted efforts to improve mining technology combined with the development of lake-based lithium extraction.[38] Traditionally, almost 70 percent of China's imports have come from Australia. The second part of the country's strategy has been to acquire lithium resources in other parts of the world. According to a report by S&P Global Market Intelligence, Chinese companies acquired 6.4 million tons of lithium reserves in 2021; they have also placed bids worth US$1.58 billion across different development stage projects.[39] The Chinese acquisitions have been led by two state-led companies, Jiangxi Ganfeng Lithium and Chengdu Tianqi Industry Group. In the early stages, Chinese companies focused on acquiring mines in Australia, bidding for three projects worth around US$900 million between 2012 2015. More recently, the focus has shifted to other countries, specifically Chile, Argentina, and Canada. In 2018, Tianqi acquired a large share in the much-vaunted Salar De Atacama brine deposits in Chile, a significant move. Bolivia is estimated to have 21 million tons of lithium and will be the newest country to come into focus. Other countries have also stepped-up efforts but remain far behind China in their efforts (See Figure 10).

Figure 9: Lithium Acquisition Deals, by Country (2018-21)



Source: S&P Global Market Intelligence.

Lithium has traditionally not been a priority for India, and there is no clear assessment of the country's lithium resources. Some reserves have been found recently, but domestic capacity will continue to remain minimal in the future. India also lacks the processing capacity to create battery-grade lithium. This will have major implications in the future. Estimating the future state of the lithium market remains difficult, given the uncertainty regarding EV adoption, politics of lithium production, and improvements in battery technology.[40] Tabelin et al. (2021) estimated that the global demand for lithium batteries could increase at a CAGR of 32 percent between 2021 and 2025. However, lithium production in the same period is expected to increase only by two to five percent.[41] Thus, demand for lithium could far outstrip production in the next few years. As a result, India will find itself on the wrong end of volatile lithium prices and will be dependent on a small set of countries to satisfy its lithium needs. This could become a major hurdle to the indigenisation of battery manufacturing as well as EV uptake in general, since the higher battery prices will translate into higher cost of EVs for consumers.

To prevent this, India must adopt an aggressive strategy of securing lithium reserves abroad while building processing capacity at home and identifying a robust battery recycling process. Recently, Khanij Bidesh India Ltd was set up as a JV between three state-run companies, to acquire strategic minerals abroad. Lithium and cobalt are top of the list. The JV aims to secure mines and purchase orders specifically in Australia and South America. However, they will have to compete in an already crowded and competitive space and likely pay a premium to secure the remaining lower-quality reserves. The Indian government will need to utilise all its diplomatic goodwill with these countries, especially Australia, and also with the existing multilateral platforms to get favourable access to these resources. The need of the hour is to scale up these efforts aggressively; even then it may not be enough to secure adequate resources, since many other countries will have the first-mover advantage.

Employment

In light of the uncertainty regarding the future evolution of the auto-component industry, future changes in employment patterns will be difficult to predict. The central issue that India must address is how much of the additive value chain for manufacturing EVs and batteries it can indigenise. Estimates from the EU suggest that there could be a net positive increase of 500,00 to 850,000 jobs.[42] However, the EU markets are markedly different from India. A study by the Council on Energy, Environment, and Water (CEEW) for India estimated that 23-25 percent lesser jobs would be supported by the automobile industry if the target of 30 percent EVs in new sales is achieved by 2030,[43] assuming that all the battery cell manufacturing remains import-dependent. However, with higher levels of indigenisation of battery manufacturing, the new jobs generated could be similar to business as usual.

Regardless of the net change in jobs, the skillsets needed for newer jobs in the EV ecosystem will differ. There will be a shift in demand for skills related to mechanical engineering to a combination of mechanical and electrical engineering. Demand will also increase for newer skillsets such as telematics, automation, artificial intelligence (AI), the Internet of Things (IoT), and data analytics. In India, however, skill development remains focused on mechanical engineering and the IT sector. Educational and skilling institutions will need to offer easily accessible programmes that can create the skilled labour force needed in the evolving automobile industry. To this end, the Ministry of Skill Development and Entrepreneurship has announced a blueprint for creating 10 million jobs in the EV space. One of the key features of this programme is the creation of EV-specific occupational standards. The Automobile Skill Development Council (ASDC) has also launched an electric mobility training programme for people with a background in engineering, and private players such as MG Motors have tied up with the ASDC to offer such courses.

While this is a good start, these initiatives must be scaled up rapidly, with a clear roadmap that accounts for the availability of professionals as well as the skill requirements. This will necessitate significant collaboration between industry, academia, and government, at a level not seen before. These courses will also have to be included in the curriculum of engineering colleges. Some institutes, such as IIT-Madras, have already taken the lead in devising master's programmes focused on e-mobility. Demand is also expected from allied sectors such as battery installation and maintenance, after-sales services, charging infrastructure setup, maintenance, and research and development, requiring additional courses to be introduced related to these fields.

While the e-mobility transition will lead to increased demand for newer skillsets, the government must also consider the future of those already employed in the component industry who are at risk of being made redundant. This is especially relevant for low-skill jobs in these sectors, such as welding, casting, and engine testing. While stakeholder insight suggests that the drop in demand for ICE parts till 2030 is not yet sufficient to lead to large-scale job losses, beyond 2030, the demand drop could be significant.

Thus, there needs to be a clear roadmap for securing existing livelihoods and creating adequate jobs for workers who will enter this space in the next decade. Existing manufacturers must have a clear roadmap for scaling down investments in ICE technologies, thereby reducing hiring for these skill sets which may become redundant in the future. The shift in investment will lead to a shift in hiring and send the right signals to the job market in terms of the future skill sets needed in the industry. Furthermore, they must also focus on developing re-skilling programs for employees whose skill sets could become redundant in the future. The auto component industry will also need to focus on catering to component demand from alternate industries. As discussed, the aerospace, defence, and agriculture industry could be potentially new sources of demand. The suppliers will have to develop a clear transition plan to enhance the capacity to serve these industries in the long term.

Policy Lessons

India's Industrial policy for electric mobility has a strong focus on indigenisation, this is seen as essential for maximising the economic co-benefits of the transition. In case of electric buses, there are already several new OEMs that have entered the manufacturing space. However, the capacity for producing critical electric vehicle components and battery packs remains negligible in India. Economic value addition and employment generation will depend, in large part, on the pace at which domestic capabilities can be built up in these areas of the value chain. However, in the short term, the mandate-based approach to indigenisation can increase vehicle costs and slow down the supply of electric buses. There is also a dependence on foreign firms for design engineering, which will impact the ability to innovate and develop a robust component and battery manufacturing ecosystem, as has been the case of ICE vehicles. Thus, while the overarching policies and schemes are strong, there is a need for a more nuanced approach in certain areas, particularly for managing imports, building an EV ready workforce, and catalysing innovation. To this end, some policy lessons are highlighted below.

Measured increases in customs duties: Custom duty hikes on EV components will translate into higher manufacturing costs for OEMs in the short term, since many of these components are not available locally. OEMs are already struggling with higher input prices and a shortage in semi-conductor availability. The proposed hikes, as part of the FAME-II scheme, have already been delayed multiple times based on the request of OEMs. Thus, it may be necessary to slow down the rate at which customs duties are being increased. In the short run, it is important to focus on reducing the cost of EV production and ensure the availability of quality products to build trust in the EV market. Local manufacturing can also benefit from imports, as it will set a quality benchmark while encouraging cost reductions.

Going forward, the roadmap for custom duties should be developed in consonance with the OEMs and with a realistic expectation regarding the growth of the local EV component industry. Such an approach will promote the growth of electric bus manufacturing in the short term and lead to more competitive local products in the long run. However, higher customs duties on the fully built and knocked-down units can still be increased to encourage local assembling of e-buses and incentivise newer firms to enter this space.

Increased focus on Innovation: The Indian automobile industry has a long history of innovating and developing cost-effective production methods. This needs to be encouraged in the transition to electric mobility as well. Accelerating R&D for EV component and battery manufacturing will be essential for India to develop indigenous knowledge and promote the use of locally-sourced material. The present PLI schemes focus on incentivising production, without a specific focus on engineering design. This can encourage Indian companies to simply adopt production methods from abroad while paying royalties and increasing the use of difficult-to-source critical minerals. To prevent this, an additional scheme should be rolled out, aimed at promoting R&D for critical EV components and the existing schemes should have conditions that will favour firms with higher spending on R&D. The government should also partner with existing research institutes to push R&D in specific areas. Newer models of technology acquisition should also be explored, and one such strategy could be the direct acquisition of foreign companies that have developed certain unique technologies. This process is quicker than developing technologies in-house and provides assured results even if the costs may be higher in the long-run. Indian firms have traditionally been averse to utilising this strategy and will need to adopt a more active approach to identify and execute such acquisitions.

Some state governments have already begun addressing this problem. Karnataka plans to set up an Electric Mobility Research and Innovation Centre, while Andhra Pradesh has committed INR 5 billion to support a Centre for Automotive Research and Mart Mobility. Bihar plans to offer funding for companies that invest INR 2 billion and generate at least 200 jobs. Other states should follow suit and include R&D as a key pillar in their EV policies.

Ensuring access to critical minerals: India must step up its efforts to acquire critical minerals such as lithium, copper-nickel, and cobalt. This will require a dual strategy of acquiring reserves and also securing future purchase orders. Since there are already many countries involved in this market, India may need to pay a premium, but this additional cost will likely be lower than the cost of being on the wrong end of the supply chain. India will need to utilise its presence on different bilateral and multilateral forums to ensure long-term access to these minerals. Further, to achieve some level of self-reliance, a strong battery recycling policy must be implemented immediately. It is expected that battery waste will increase significantly by 2025, by when India needs to have a strong battery recycling system in place to recover as much of the critical minerals as possible. Some states have already started incentivising recycling, but a strong policy at the central level is needed. Proper standards for recycling should be developed on priority.

Greater coordination with Industry: Policies that affect the auto industry often face implementation issues due to a lack of deliberation in the planning stages, as has been witnessed in the multiple revisions to policies related to component imports. Going forward, collaborative platforms should be set up where policymakers can take on industry inputs, as the different PLI schemes progress. Specific committees can be set up to focus on different components and their progress towards indigenisation. These committees should have wide representation from policymakers, the component industry, as well as research institutes. The recommendations from these committees should directly inform the evolution of the existing policies and form the basis of newer policies.

Standardisation and testing facilities: DHI and other government agencies should set specific standards for all EV components. This will help create concentrated demand for components, which is one of the challenges to achieving economies of scale. Further, testing labs should be set up to provide technical guidance, design inputs, and carry out simulation testing of EV components. The incentives under the PLI schemes can also be linked to the quality of products as assessed by the testing process.

Offering direct financing to EV component industry: Despite the PLI schemes, firms entering the EV component space will need to invest large amounts as upfront capital. It is imperative for government grants, international investors, and development agencies to channel direct green funds towards the EV component industry. The national-level PLI schemes should have some consideration for MSMEs, either by relaxing investment criteria or setting aside a specific allocation. Specific programmes must be designed to encourage funding for start-ups in the component space. These funds should also be directed towards reskilling programmes, to allow more people to access jobs in the future EV component industry.

India's industrial policy for electric mobility has a strong focus on indigenisation, and this is seen as essential for maximising the economic co-benefits of the transition.

Summary

The transition to electric mobility is being driven by policies at both the national and sub-national levels. Electric buses, in particular, receive large subsidies from the Central and the state governments. Currently, these subsidies are only extended to the public sector, with electric bus uptake being limited to the SRTUs. However, given the financial strain on SRTUs, burdening them with additional expenditures could lead to reduced investment in other parts of the system. For SRTUs to successfully bear the burden for purchasing electric buses, it is imperative to first improve their financial situation. To this end, these entities must be positioned and run as professional businesses, not unaccountable state-run agencies. In the long run, large-scale electrification of the bus fleet will depend upon getting more private players involved. Policies will thus need to be adapted to bring in more private players, either directly or through PPP arrangements.

India must also explore the notion that any improvement to the public bus system, electric or not, is positive. Given that the electricity grid in India is largely coal powered, the higher investment in electric buses will not lead to immediate gains in terms of lifecycle emissions. It is imperative to develop an investment roadmap, with investment in electric buses being scaled up only when battery prices come

down and electricity becomes cleaner. In the meantime, the Union government should continue direct bus procurement programmes, including diesel, CNG and LNG buses. With the second stage of Bharat Stage 6 (BS6b) norms coming into play by 2023, emissions of particulate matter and nitrous gases from ICE buses fill fall further. Strict enforcement of the CAFE norms for commercial vehicles will lead to significant improvements in fuel efficiency. The increased uptake of CNG and LNG buses can provide emission and cost savings as well. The ultimate goal should be to achieve the benchmark public transport service levels as the most effective way to keep people away from private vehicles and the associated negative externalities.

The electric transition will also have significant implications for the bus manufacturing ecosystem. Legacy OEMs have already started adapting their platforms to build e-buses, while newer firms have emerged, creating their own e-bus platforms. Despite the significant competition in the e-bus manufacturing space, the OEMs are essentially assemblers who source components from a variety of suppliers. The e-mobility transition will have much more severe consequences for the components industry. The manufacturing of engines and transmissions, most of which happen in India, have already led to the creation of a large and vibrant components industry. While some component players such as JBM have made the full shift to e-buses, others remain apprehensive that a large, unplanned shift to could devastate the industry. Electric vehicles have less than a tenth of the moving parts of an internal combustion engine and rely on parts that are currently completely import-dependent. Going forward, mass import of components for these new vehicles, particularly from China, is a clear and present danger to India's employment landscape, as well as its ambition to grow automobile employment by one-third. Manufacturers argue against rushing into e-mobility transition without more supply-side interventions to ensure that Indian manufacturing is not adversely impacted.

The transition to producing EV components will happen as a mixture of existing suppliers who will pivot and newer firms entering the market. However, newer firms will have some advantages and very minimal barriers to entry. Since the PLI scheme incentivises newer firms, they will be able to avail of incentives if they meet the revenue and investment criteria. Further, the production of EV components requires very different processes compared to engine components. Largely, the technical know-how is related to knowledge and platforms for producing electronic systems. This will be an advantage for firms that have prior experience in these systems. However, they will face significant challenge in acquiring the capital investments required to pivot to newer systems.

The Union and state governments have already taken several proactive steps to support indigenous manufacturing. There is also an increasing focus on implementing skilling programmes that can create the skillsets required in the mobility system. All these policies have very strong conditions for local value addition. This is a strong signal that import dependence is unacceptable. This will have some negative implications in the short run because imported technology is currently both cheaper and of a higher quality. Costs will only come down if major economies of scale can be achieved. Further, there is a need to develop local manufacturing techniques and not just import knowledge from abroad. To this end, more needs to be done to push R&D and not just manufacturing. There should be an additional Central scheme aimed at promoting R&D for critical EV components and the existing schemes must favour firms with higher spending on R&D. The government should also partner with existing research institutes to push R&D in specific areas, especially for battery manufacturing, since this can accelerate the shift to newer non-lithium battery chemistries. This will be essential given the expected future difficulties associated with lithium imports.

Stakeholders in the components industry have adopted a "wait and watch" attitude. One official stated that the government gets very excitable very quickly, without really considering the implications on India's manufacturing base. Another OEM executive sums up the situation from the perspective of both OEMs and component suppliers: "Putting out thousands of newer buses, even if they are diesel, CNG or LNG can dramatically reduce the number of private vehicles on the road while promoting indigenous manufacturing. India has the manufacturing capabilities in all these fuel systems and they are significantly more affordable than electric buses at present. If one bus can take 25-50 two-wheelers and a few cars off the road, it would have cut emissions significantly by its very presence. We can and will make electric buses but in the shiny bright lights of electric buses we should not forget our priorities."

Annexure

The following stakeholders were interviewed as part of our consultations. Since the conversation were done without attribution, only the organisations contacted are listed; however, the views expressed by the interviewees are personal and not the views of their organisations.

Original Equipment Manufacturers

Ashok Leyland

Tata Motors

VE Commercial Vehicles

Industry Bodies

Society of Indian Automobile Manufacturers (SIAM)

Automotive Component Manufacturers Association (ACMA)

Society of Manufacturers of Electric Vehicles (SMEV)

Public Agencies

Delhi Transport Corporation (DTC)

West Bengal State Transport Corporation (WBSTC)

Delhi Government

Private Organisations

Insightzz

International Association for Public Transport (UITP)

The consultations also included conversations with three private equity investors with an interest in electric bus operations and two start-ups involved in the manufacture of EV charging equipment

Endnotes

1 Press Information Bureau, *Household expenditure on services and durable goods NSS 72nd round (July, 2014 –June, 2015)*, 2016.

2 Geetam Tiwari, "Urban transport priorities: meeting the challenge of socio-economic diversity in cities, a case study of Delhi, India." *Cities* 19, no. 2 (2002): 95-103.

3 NITI Aayog & The Boston Consulting Group, *Transforming India's Mobility: A perspective*, 2018.

4 International Road Federation, *World Road Statistics*, 2018.

5 Ministry of Housing and Urban Affairs, *Study on traffic and transportation policies and strategies in urban areas in India*, 2008.

6 John Pucher, Nisha Korattyswaropam, Neha Mittal, and Neenu Ittyerah. "Urban transport crisis in India." *Transport Policy* 12, no. 3 (2005): 185-198.

7 Nielsen, *All India Study on Sectoral Demand of Diesel & Petrol*, 2013.

8 India GHG Program, *India Specific Road Transport Emission Factor*, 2015.

9 Ministry of Road Transport and Highways (MoRTH), *Review of the Performance of State Road Transport Undertakings for April, 2016 - March, 2017*, 2018.

10 Ministry of Road Transport and Highways (MoRTH), *Vahan4 Statistics*, January 10,2022.

11 Ministry of Road Transport and Highways (MoRTH), *Electric Vehicle operational in Medium and Heavy Passenger Vehicle category register an increase*, August 05,2021.

12 Nehal Chaliawala, "EV Push: FAME-II scheme achieves just 10% target with 4 months left in original deadline." *The Economic Times,* November 29, 2021.

13 Ministry of Housing and Urban Affairs, *Service Level Benchmarks for Urban Transport*, n.d.

14 Census of India 2011, *Population Projections for India and States 2011 – 2036: Report of The Technical Group on Population Projections,* 2019.

15 Vijaykumar, Aparna, Kumar Parveen, Muluktala Pawan, and Agarwal OP. "Procurement of Electric Buses: Insights from Total Cost of Ownership (TCO) Analysis." *World Resources Institute-India*, 2021.

16 BloombergNEF. "Battery Pack Prices Fall to an Average of $132/kWh, But Rising Commodity Prices Start to Bite." November, 2021.

17 Ravi Gadepalli, Kumar Lalit, Nandy Rupa. "Electric Bus Procurement under FAME II: Lessons Learnt and Recommendations for Phase-II." *International Association of Public Transport (UITP)*, 2020.

18 "Lowering battery costs key to EVs taking off in India." *Financial Express*, August 18, 2021.

19 Special Correspondent. "Over ₹30,000-crore loss to TNSTC in last decade: Transport Minister." *The Hindu,* July 29,2021

20 Staff Reporter. "TSRTC suffers loss of ₹2,600 crore." *The Hindu*, August 14,2021

21 Somit Sen. “Maharashtra okays Rs 600 crore bailout package for loss-making MSRTC.” *The Times of India,* June 10,2021.

22 Central Electricity Authority (CEA), *Central Electricity Authority: CO2 Baseline Database*, 2019-20.

23 World Population Review, *Car production by Country 2021*, 2021.

24 Grant Thornton and Confederation of Indian Industries (CII), *India’s Readiness for Industry 4.0: A Focus on Automotive Sector*, 2020

25 Nation Master*, Buses and Coaches Production*, 2019.

26 Automotive Component Manufacturers Association (ACMA). *Indian Auto Component Industry Performance FY19*, 2020.

27 Ministry of Road Transport and Highways (MoRTH). *Road Transport Yearbook (2016-17)*, 2018.

28 India Brand Equity Foundation, *Auto Components Analysis*, 2021.

29 Mckinsey & Company, *The auto component industry in India: Preparing for the future*, 2018.

30 Automotive Component Manufacturers Association & Yes Bank, *EV Landscape: Opportunities for India’s Auto Component Industry*, 2021.

31 Nomura Research Institute Consulting & Solutions India Pvt. Ltd, *Holistic Assessment of Alternate Powertrains for Passenger Vehicles in India*, 2021

32 Special Correspondent. “Huge opportunity for Indian auto component suppliers.” *The Hindu,* November 26,2014.

33 Chaitanya Kanuri, Rohan Rao, Muluktala Pawan. “A Review of State Government Policies for Electric Mobility.” *World Resources Institute-India*, 2021.

34 Neha Yadav and Pawan Muluktala. “Tracking India’s Industrial Evolution with Electric Mobility.” *WRI India- Ross Center.*

35 Akifumi Kuchiki. "The flowchart model of cluster policy: the automobile industry cluster in China." *IDE (Institute of Developing Economies) discussion papers* 100 (2007).

36 Paul W. Gruber, Pablo A. Medina, Gregory A. Keoleian, Stephen E. Kesler, Mark P. Everson, and Timothy J. Wallington. "Global lithium availability: A constraint for electric vehicles?" *Journal of Industrial Ecology* 15, no. 5 (2011): 760-775.

37 US Geological Service, *Lithium Statistics*, 2021

38 Staff Reporter. “China's heavy reliance on lithium from Australia may ease with rising domestic supplies,” *Global Times,* July 18, 2021.

39 Kip Keen and Camille Erickson, “China mining, battery companies sweep up lithium supplies in acquisition blitz.” *S&P Global Market Intelligence,* Nov 1, 2021.

40 Donghui Liu, Xiangyun Gao, Haizhong An, Yabin Qi, Xiaoqi Sun, Ze Wang, Zhihua Chen, Feng An, and Nanfei Jia. "Supply and demand response trends of lithium resources driven by the demand of emerging renewable energy technologies in China." *Resources, Conservation and Recycling* 145 (2019): 311-321.

41 Carlito Baltazar Tabelin, Jessica Dallas, Sophia Casanova, Timothy Pelech, Ghislain Bournival, Serkan Saydam, and Ismet Canbulat. "Towards a low-carbon society: A review of lithium resource availability, challenges and innovations in mining, extraction and recycling, and future perspectives." *Minerals Engineering* 163 (2021): 106743.

42 Yoann Le Petit. “How will electric vehicle transition impact EU jobs?” *Transport & Environment,* September 12, 2021.

43 Abhinav Soman, Ganesan Karthik, and Kaur Harsimran. “India’s Electric Vehicle Transition: Impact on Auto Industry and Building the EV Ecosystem.” *Council on Energy, Environment and Water,* 2019.

About the Authors

Promit Mookherjee is an Associate Fellow at ORF's Centre for Economy and Growth.

Kushan Mitra is a journalist with over two decades of experience and has covered the global automotive, mobility and transportation industries extensively.

OBSERVER RESEARCH FOUNDATION

Ideas . Forums . Leadership . Impact

20, Rouse Avenue Institutional Area,
New Delhi - 110 002, INDIA
Ph. : +91-11-35332000. **Fax :** +91-11-35332005
E-mail: contactus@orfonline.org
Website: www.orfonline.org

d·i·e

Deutsches Institut für Entwicklungspolitik

German Development Institute

German Development Institute /
Deutsches Institut für Entwicklungspolitik (DIE)
Tulpenfeld 6, D-53113 Bonn, Germany
E-mail: DIE@die-gdi.de
Phone: +49 (0)228 94927-0
Website: www.die-gdi.de/en/