WRI INDIA

ASDC
AUTOMOTIVE SKILLS DEVELOPMENT COUNCIL

CONFERENCE PROCEEDING

Creating holistic and skilled enterprises for a smooth and just transition to electric mobility

A SUMMARY OF EXPERT PERSPECTIVES

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BACKGROUND

The electric vehicle (EV) transition in India has accelerated in recent years, driven by the growing need for transport-sector decarbonization, supportive policies, timely incentives, increased consumer interest, and advances in vehicle and battery technology. However, the shift from traditional internal combustion engine vehicle (ICEV) powertrain to EV powertrain, which requires drastically fewer components, introduces considerable challenges for the automotive supply chain. Automotive original equipment manufacturers (OEMs) and component manufacturers will have to adapt to changing manufacturing technologies, adopt appropriate diversification strategies, and reskill their workforce to avoid transitional risks and leverage opportunities in the EV supply chain and manufacturing.

Recognizing the urgency of these changes, WRI India initiated various in-depth engagements with key automotive industry stakeholders in the western auto cluster in Maharashtra. These engagements aimed to facilitate a comprehensive understanding of the industry's needs and support the development of resilient enterprises capable of thriving during the EV transition. As part of this initiative, WRI India, in collaboration with the Automotive Skills Development Council and local industry associations i.e., the Nashik Industries and Manufacturers' Association in Nashik, and the Centre of Excellence (CoE)–Gokul Shirgaon Manufacturers' Association (GOSHIMA) in Kolhapur, organized a series of workshops on 'Creating Holistic Enterprises for a Smooth and Just Transition to Electric Vehicles' in three major automotive hubs in Maharashtra: Pune, Nashik, and Kolhapur. These workshops were designed to create awareness regarding opportunities in EV and EV component manufacturing and to explore industry perspectives

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These conference proceedings reflect the presentations and discussions of participants and do not necessarily represent the views of WRI India or other participating institutions.

on the support needed for this transition. Participants included OEMs, auto-component manufacturers, firms from adjacent industries (e.g., mechanical, electronics, motors) seeking to enter the EV industry, and representatives from the automotive skilling ecosystem.

The carefully curated sessions included addresses from industry stakeholders and domain experts, as well as interactive discussions among participants. The key discussion themes included:

- Strengths of different auto clusters regarding their capacity to support local industries in driving the region's EV transition;
- Diversification opportunities and strategies for both legacy auto-manufacturing firms and start-ups as a result of EV transition;
- Changes in job roles and skills owing to the EV transition and strategies for EV-oriented skill development;
- Financing requirements and challenges in diversifying to EV manufacturing in terms of research and development (R&D) and infrastructure;
- Support for micro, small, and medium enterprises (MSMEs) regarding infrastructure, industry initiatives, and policies to enable their transition to EV manufacturing;
- Innovation and incubation facilities for EV start-ups; and
- Government policy and regulatory interventions for facilitating a vibrant EV manufacturing ecosystem.

As underscored by the workshops, while the EV transition offers multiple opportunities for growth, it also presents challenges, particularly for vulnerable stakeholders such as MSMEs. Therefore, understanding industry needs and developing ecosystem-wide interventions in areas such as infrastructure, technology, policies and regulations, financing, skill development, innovation, and incubation are essential for a seamless, inclusive transition to EVs. This conference proceeding outlines the key learnings and action points from the workshops.

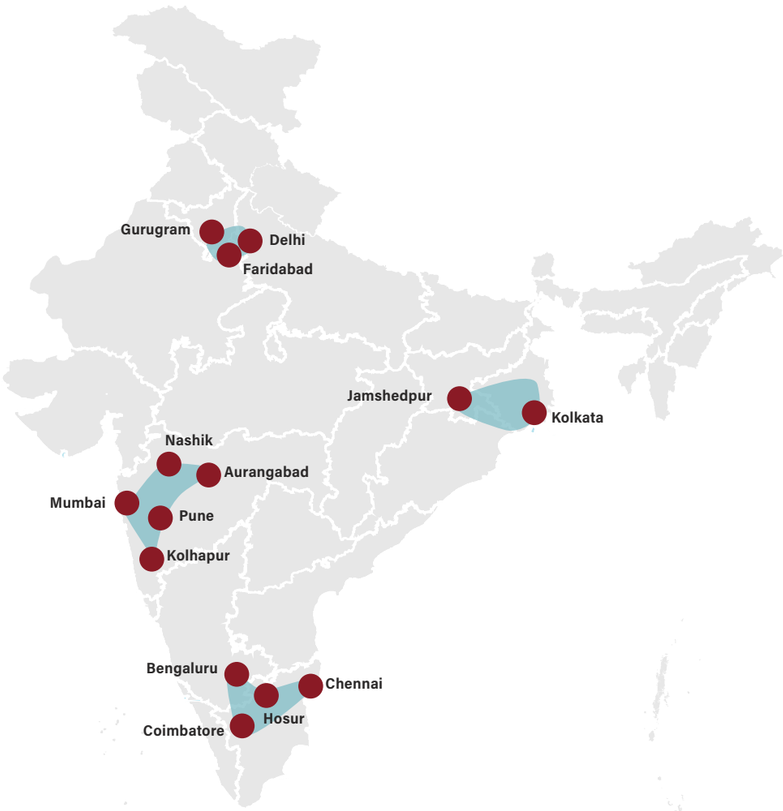
INTRODUCTION

The facts presented in the following two sections ('Introduction' and 'The Automotive Industry in Maharashtra') were shared by experts, speakers, and moderators during the workshops to set the context for group discussions. These facts have been verified using secondary sources before inclusion here.

The transition to EVs is integral to the global strategy for combating climate change and decarbonizing the transport sector, which contributes over 25 percent of global energy-related greenhouse gas emissions (United Nations Environment Programme n.d.). Serving the third-largest automobile market in the world, India's automotive industry—from manufacturing to after-sales—substantially contributes to the country's economic growth and development. This sector accounts for 7.1 percent of India's gross domestic product (GDP) and approximately 49 percent of its manufacturing GDP, in addition to 4.7 percent of the country's total exports. Similarly, the domestic auto-components industry has grown in tandem with the broader automotive sector, currently accounting for 2.4 percent of India's GDP (Saxena 2024). The industry spans four primary clusters: Delhi-Gurugram-Faridabad in the north, Mumbai-Pune-Nashik-Aurangabad-Kolhapur in the west, Chennai-Bengaluru-Hosur-Coimbatore in the south, and Jamshedpur-Kolkata in the east (KPMG and Ministry of MSME 2020).

Additionally, India's automotive and transport sectors directly and indirectly employ approximately 3.7 crore people, of which automotive manufacturing accounts for roughly 50 lakh jobs (Ernst & Young 2019; Saxena 2024). However, the automotive sector relies on a large number of MSMEs. Approximately 35,000–45,000 MSMEs that produce over 2,000 components for ICEVs account for 43 percent of the automotive sector

FIGURE 1 | The primary clusters of India's automotive and auto-components industry



DISCLAIMER: This map is for illustrative purposes and does not imply the expression of any opinion on the part of WRI India concerning the legal status of any country or territory or concerning the delimitation of frontiers or boundaries.
Source: KPMG and Ministry of MSME 2020.

workforce. This reliance highlights the sector's inherent vulnerabilities, as smaller firms and their workforce may face greater risks than their larger counterparts during times of adversity or transition (Gupta et al. 2023a; Gupta et al. 2023b). Furthermore, as automotive firms tend to be clustered in specific regions, clusters with high concentrations of MSMEs may also face socioeconomic risks that affect local communities if firms are unable to navigate the EV transition successfully.

Thus, the ongoing EV transition presents a dichotomy in the Indian automotive industry. On one hand, the industry has the potential to become an important contender in the global EV market. India's overall vehicle production is expected to double by 2030–31, with EV penetration reaching a record high of 29–38 percent (depending on different policy scenarios) in that timeline (iFOREST 2024a). This growth aligns with the Government of India's (GoI) target of 30 percent EV penetration by 2030. The transition's accelerated pace is also supported by proactive government policies, such as the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) and the Production Linked Incentive (PLI) schemes, and state-level EV policies providing demand and manufacturing incentives.

The EV transition also presents numerous business opportunities for enterprises able to adapt through infrastructure upgrades and workforce reskilling. These opportunities include design and development of new EV models; manufacturing of motors, batteries, and charging stations; and advancements in power electronics and software (Saha et al. 2024). The EV transition will also drive demand for second-life battery applications and battery recycling.

On the other hand, the transition is expected to bring about changes in manufacturing technology and create disruptions across the automotive supply chain, placing vulnerable businesses and workers at risk. Owing to significant powertrain differences, approximately 45–84 percent of ICEV parts may become redundant in EVs, and MSMEs working in ICEV powertrain component manufacturing will be impacted if they cannot diversify. Although the transition may lead to a net increase in jobs, close to 21.4 percent of auto-manufacturing roles may become obsolete with 12.3 percent requiring reskilling (iFOREST 2024a).

MSMEs may also face considerable challenges in the form of limited access to technology, inadequate awareness of the EV transition, insufficient financing for retooling machinery and upgrading workforce skills, and uncertainties surrounding EV supply chains and technologies; the lack of a supportive ecosystem for localized manufacturing exacerbates these difficulties (Mane 2024). Addressing these challenges and thereby enabling a just transition to e-mobility in India requires a roadmap that promotes business diversification, the development of new skill sets, and the building of new supply chain linkages. Given that industrial development falls under state jurisdiction in India, state-level action is critical for creating the necessary conditions for a strong EV and EV component manufacturing industry.

THE AUTOMOTIVE INDUSTRY IN MAHARASHTRA

Maharashtra, which produces over 20 and 21 percent of automobiles and automotive components, respectively, in the country, is well-positioned to capitalize on the EV transition. The state's automotive sector directly employs at least 3.4 lakh people and has emerged as a leader in EV adoption, with approximately 4.7 lakh EV sales as of May 2024, representing roughly 13 percent of national EV sales. However, despite its strong presence in ICEV manufacturing, Maharashtra faces increasing competition from states such as Tamil Nadu, Karnataka, Telangana, and Gujarat in establishing itself as an EV manufacturing hub. To maintain its competitiveness and attract further investment in EV manufacturing, Maharashtra must proactively ensure an equitable and inclusive EV transition. Such a strategy could help leverage opportunities for economic development and job creation (MCCIA and KPMG 2024; iFOREST 2024b).

It is worth noting that 65 percent of the state's automobile enterprises are concentrated in six districts—Pune, Aurangabad, Kolhapur, Thane, Mumbai Suburban, and Nashik—making these regions, which have thrived with ICEV manufacturing, highly vulnerable to EV transition.

Approximately 99 percent of the automobile enterprises in these districts are MSMEs, which typically have less access to information, technology, and capital; this can adversely impact their ability to navigate technology transitions. Furthermore, these six districts account for over 83 percent of the formal workforce engaged in automotive OEMs and component manufacturing in the state. Table 1 provides data on the auto enterprises and formal workforce employed across these six districts (iFOREST 2024b).

FIGURE 2 | Key automobile clusters in Maharashtra

DISCLAIMER: This map is for illustrative purposes and does not imply the expression of any opinion on the part of WRI India concerning the legal status of any country or territory or concerning the delimitation of frontiers or boundaries.
Source: iFOREST 2024b.

TABLE 1 | Auto enterprises and formal workforce employed across six clusters in Maharashtra

Cluster	Number of OEMs (A)	Number of large enterprises (B)	Number of MSMEs (C)	Number of formal workers employed in A, B, and C
Pune	23	56	4,170	180,610
Aurangabad	2	7	1,641	30,631
Kolhapur	0	2	1,689	23,488
Thane	1	3	1,266	14,463
Mumbai Suburban	0	3	1,174	13,150
Nashik	0	6	857	16,738
State total - Maharashtra	26	100	16,476	335,237

Source: iFOREST 2024b.

Among the six key automotive clusters in Maharashtra, three were selected for the EV awareness workshops for the following reasons:

- The industry associations in these clusters expressed interest in hosting such workshops and supporting future capacity-building initiatives aimed at preparing local industries for the impending technology transition.
- Each of the selected clusters has unique strengths in different manufacturing areas that can be appropriately leveraged for the transition. Pune specializes in vehicle and powertrain manufacturing, whereas Nashik and Kolhapur are hubs for electronics, foundries, and engineering.
- Each cluster accounts for a very high share of the formal workforce employed in Maharashtra's automotive sector, with Pune and Kolhapur ranking in the top three.

Pune is the largest hub for major automotive OEMs in Maharashtra, with the influx of Tier I and II industries driven by major domestic players such as Tata Motors, Bajaj Auto, and Mahindra & Mahindra and international companies such as Mercedes-Benz, Ford, and Skoda. The city hosts several key automotive institutions, including the Automotive Research Association of India (ARAI) (Kuwajima et al. 2010).

In contrast, Nashik has developed into a major supplier of mechanical and electrical components. It is strategically positioned within the "golden triangle" of Maharashtra, linking it to the two major industrial hubs of Mumbai and Pune (KPMG 2020).

While Pune and Nashik specialize in vehicle and/or component manufacturing, Kolhapur is a foundry and engineering cluster, home to many process-based companies. The region plays a vital role in manufacturing castings for cylinder heads, clutch housings, and gears, with some larger, highly mechanized units producing engine castings; 42 percent of the castings produced in the region are for automotive/oil engines (The Energy and Resources Institute 2012).

WORKSHOP OUTCOMES: KEY LESSONS AND ENTRY POINTS FOR ACTION

This section outlines the key insights and recommendations regarding the types of transitional support required by enterprises in Maharashtra's key automotive clusters, as proposed by experts and industry participants from the workshops in Pune, Nashik, and Kolhapur. Discussions highlighted the need for multipronged interventions to enable a seamless transition for automotive firms in the state. Their suggestions focused on skill development, financial interventions, cluster-level initiatives, and policy alignment to facilitate resilient enterprises.

Each automotive cluster has unique opportunities that can be leveraged to build a robust EV manufacturing ecosystem

A technology transition, such as that introduced by EVs, will likely have varied impacts on the state's key automotive clusters. According to workshop participants, each cluster has certain advantages and drawbacks shaped by local factors including infrastructure, finance, technological innovation, human resources, labor conditions, and support from ancillary industries.

Pune: With over 4,000 automotive manufacturing and ancillary units in the Pimpri-Chinchwad region alone, Pune has emerged as a hub for automotive innovation (MCCIA and KPMG 2024). The city hosts many well-established automotive OEMs, which facilitates a robust supply chain for regional vehicle manufacturers. The region leads in the number of MSME suppliers and benefits from robust infrastructure supporting local automotive manufacturing industries and skilling institutions, providing a strong foundation for driving transition-related changes. The region also boasts several institutions dedicated to the automotive industry, including the Auto Cluster Development and Research Institute (ACDRI), ARAI, and the Central Institute of

FIGURE 3 | Just transition awareness workshop in Pune

Photo credit: Shrikant Gangapurkar, MCCIA, Pune.

Road Transport (CIRT). ACDRI supports local MSMEs in meeting customer expectations regarding product development, reliability, quality, and cost through services such as design, prototyping, testing, incubation, and skill development. ARAI and CIRT focus on R&D, testing, certification, and homologation of vehicles, systems, and components.

In addition to Pune's excellent ecosystem for automotive innovation and infrastructure, a collaborative network exists between MSMEs and city educational institutions. According to industry representatives, such networks will be instrumental in fulfilling the transition-related skilling needs of MSMEs and start-ups in the EV manufacturing sector.

Several well-established educational institutions have already recognized the importance of the EV transition, which can further help leverage the benefits from such collaborative networks. For example, the College of Engineering Pune (CoEP) and the ARAI Academy introduced a collaborative program offering a specialization in EV technology.

Pune's access to several high-quality educational and research institutes is an asset for new EV start-ups entering the automotive industry. These start-ups are actively collaborating with academic institutions to facilitate understanding of technological advancements. For instance, a prominent EV start-up specializing in lithium-ion battery manufacturing has been engaging with universities across Pune to gain insight into battery-related innovations.

The region is also home to innovation hubs and centers of excellence (CoEs) focused on EV technology development along the value chain. For example, ACDRI supports MSMEs and start-ups by providing component development services. Other CoEs in e-mobility are being established within educational institutions, such as the CoEP through partnerships with global technology companies and local R&D institutions like ARAI, which help drive automotive industry innovation.

Nashik: Located strategically near the major automotive markets of Pune and Mumbai, Nashik has emerged as a key hub in Maharashtra for EV-related technological advancements. According to industry representatives, its excellent connectivity with other automotive hubs enables local component manufacturers to form part of robust local supply chains, which are essential for auto manufacturers. Additionally, the presence of legacy

OEMs such as Mahindra & Mahindra and component manufacturers like JBM Auto and Bosch further strengthens the region's role in the automotive ecosystem. The emergence of EV start-ups specializing in electric two-wheeler manufacturing, such as Revamp Moto, Hayasa E-Mobility, and Jitendra New EV Tech, present more opportunities for emerging auto-component enterprises to enter their supply chains.

Another advantage is Nashik's robust engineering cluster, particularly in electronics, specifically switchgears, which can be harnessed for power electronics for EVs. Moreover, Nashik's rapid prototyping facilities for plastic and metal components provide impetus to the local EV manufacturing landscape, reducing the overall cost of production and making the region more commercially viable and competitive in EV component manufacturing.

Kolhapur: Renowned as a foundry and engineering hub in Maharashtra and a major supplier of castings for the automotive sector, Kolhapur stands at the cusp of a transformative opportunity. Industry representatives reported that the region's innate entrepreneurial acumen can drive the integration of new technologies into its current processes, which can facilitate multiple diversification opportunities for the local enterprises' adaptation and subsequent success in the evolving auto sector.

For instance, local enterprises currently producing ferrous castings can explore aluminum castings, which meet the lightweight requirements of EVs. By slightly modifying their current processes, they can continue supplying castings for multiple powertrain and non-powertrain components in EVs, including battery casings, chassis parts, and brake systems. Similarly, moving from internal combustion engines to batteries has opened new opportunities for polymer use. Regional firms can leverage their expertise in metal fabrication, which has multiple applications both in the auto sector and other industries. The cluster's strength in working with ferrous and non-ferrous metals can be harnessed to develop capacities in metallurgical engineering for producing ferrite magnets, a potential alternative to the rare-earth magnets used in EV motors.

Entry points for action: The diverse contexts and specializations of established automotive clusters highlight the need for tailored interventions to facilitate the EV transition in each cluster. Workshop participants recommended conducting a cluster-level risk mapping and needs assessment exercise to effectively plan these interventions. This would help identify both common and context-specific requirements of Maharashtra's auto clusters, ensuring the creation of an enabling ecosystem for the EV transition. Comprehensive cluster transition plans developed with companies, local industry associations, investors, and policymakers, can provide roadmaps for a planned and contextualized transition to EV and EV component manufacturing and other diversification opportunities, according to the participants. These plans would support at-risk ICEV MSMEs, ensuring their adaptation to market demands, and create opportunities for regional economic growth.

Different firms in a cluster can diversify into EV manufacturing using distinct, strength-based strategies

The EV transition offers a range of product diversification opportunities for traditional automotive businesses, new start-ups, and non-automotive businesses because of the new or modified components required for EV powertrains. In EVs, the internal combustion engine is replaced by a battery pack and battery management system, the fuel supply system by high-voltage cables, and the transmission system by an electric drivetrain unit mainly consisting of an electric motor and motor controller. EVs also have many more power-electronic components than ICEVs: vehicle functionality is controlled by a complex vehicle control unit instead of the simpler electronic control units used in ICEVs. Currently, many of these components and sub-components are imported from countries like China, Taiwan, Singapore, and South Korea, while the assembly is done locally. However, India's push to become an "*Atmanirbhar*" (self-reliant) global EV manufacturing hub is gaining momentum, as OEMs and auto-component manufacturers work toward diversifying their portfolios to include EVs and their components.

EV manufacturing, sales, operations, and maintenance have the potential to generate opportunities for multiple industries, including core mechanical, electrical, electronics, telecommunications, foundry and engineering, rubber and plastics, software, material technology, and data analytics. Insights from experts and

TABLE 2 | EV-related manufacturing opportunities for different component manufacturers from the mechanical sector

Manufacturer/ component category	Potential opportunities (R&D and manufacturing)	
Metal and chassis components	▪ Metal components required in EVs ▪ Lightweight, high-strength chassis for EVs using advanced materials (e.g., carbon fiber composites, high-strength alloys) ▪ Monocoque chassis for electric two- and three-wheelers	
Motor casings	▪ Castings and extrusions required in EVs ▪ R&D and innovation for new technologies in casted and extruded motor casings	
Motor components	▪ Specialized EV motor components ▪ Advanced windings (e.g., hairpin, flat wave) and insulation for improved EV motor efficiency ▪ Magnets made of rare earth and alternative materials ▪ Different types of compact motors suitable for various EV applications	
Battery enclosures and thermal management	▪ Battery pack manufacturing ▪ Innovative battery enclosures using advanced materials for lightweight, robust casings ▪ Effective thermal management systems such as liquid/oil/air cooling, in-channel cooling, and new materials for battery and powertrain system cooling	
Transmission systems	▪ Transmission systems tailored to EV needs ▪ Specialized EV gearboxes with optimized torque and efficiency ▪ Regenerative braking systems for enhanced energy recovery	
Wheels and suspension	▪ Heavy-duty tires with low resistance and low noise, vibration, and harshness for improved range and efficiency ▪ Lightweight alloy wheel rims for improved EV efficiency ▪ Innovations in suspension systems for enhanced ride comfort and stability	

Source: Authors' analysis.

workshop participants outlined in Tables 2 and 3 highlight the diversity of opportunities available for both auto- and non-auto-component manufacturers in the EV supply chain. Depending on existing capabilities, process-based enterprises or component manufacturers specializing in mechanical, electrical, or electronic components for the auto sector can capitalize on these opportunities. Similarly, component manufacturers from other sectors can expand their portfolios to include EV components based on their existing capabilities and interests.

TABLE 3 | EV-related manufacturing opportunities for different component manufacturers from the electrical and electronics sector

Manufacturer/ component category	Potential opportunities (R&D and manufacturing)
Power electronics and control systems	▪ High efficiency DC-DC converters and inverters ▪ Motor controllers ▪ Semiconductor manufacturing and printed circuit board fabrication ▪ Vehicle control units ▪ Transmission control units
Battery technologies	▪ Advanced battery solutions with high-end electronics and software programming ▪ Battery pack manufacturing ▪ Lithium-ion cell manufacturing using different cell chemistries ▪ R&D and innovation in advanced solid-state batteries and other battery chemistries ▪ Recycling and second-life applications for lithium-ion batteries
Battery management systems	▪ Battery management systems with the following: ▫ Integration of state-of-charge and state-of-health monitoring ▫ Integration of smart algorithms for battery pack balancing and longevity
IoT solutions and connectivity	▪ Integrated IoT solutions for vehicle-to-grid communication ▪ Integrated intelligent solutions ▪ Cybersecurity measures for EV data protection

Source: Authors' analysis.

Firms within each automotive cluster can pursue diversification strategies based on their strengths as well as their region's specific manufacturing capabilities. For example, Nashik-based enterprises can focus on specialized electronic components or power electronics for EVs, whereas those in Kolhapur can diversify by producing non-ferrous and plastic-based castings and precision components to meet EV weight requirements. Similarly, Pune-based firms can focus on diversifying to EV powertrain or vehicle assembly, capitalizing on the cluster's comparative advantage.

Entry points for action: Industry stakeholders emphasized the role of raising firms' awareness regarding the future scope of the EV transition (including market size and investment trends) and potential EV-related opportunities in motivating them to diversify into EV-related manufacturing. Industry associations in different clusters can collaborate with their respective district industry centers to organize buyer–seller or B2B meetups to provide MSME manufacturers with platforms to interact with potential EV customers. Additionally, these associations can help create a supportive cluster-level manufacturing ecosystem by facilitating support for infrastructure upgrades, skill development, and affordable shared facilities for prototyping and testing, encouraging enterprises of all sizes to diversify effectively.

Job roles are evolving with the EV transition, making targeted skill development key for an inclusive transition

Due to technological differences, EV component manufacturing and EV assembly differ from that of ICEVs, which is a concern for auto manufacturers. These changes will require new competencies on production floors, among techno-managerial staff, and in the after-sales (maintenance and servicing) ecosystem. As EVs become more prevalent, core mechanical skills required in ICEV manufacturing will diminish in importance, and new skill sets focused on electrical and electronics manufacturing will grow in demand.

Industry representatives noted that manufacturing processes for non-powertrain parts or parts common to the two powertrains will not experience major changes. However, the demand for processes related to the design, manufacturing, and servicing of engine components, fuel and exhaust systems, and certain ICEV transmission parts may decrease as the EV transition progresses. From a skills perspective, this shift will moderately impact blue-collar roles, as many existing skillsets can be repurposed for manufacturing other products by these core mechanical process-oriented companies. Hence, common skills required on component manufacturer production floors, such as turning, fitting, welding, machining, and general electrical assembly, will remain relevant in the auto industry but will require some upskilling to align with new technology. Conversely, white-collar roles in design and engineering might require considerable skill upgrades to meet the demands of new products that ICEV firms may diversify into.

The manufacturing processes of new EV powertrain components differ considerably from those of ICEVs, requiring a fresh set of skills. A combination of electrical, electronic, mechanical, and software skills will be critical for automotive firms transitioning to EVs or for new EV start-ups, according to industry participants. Additionally, end-of-line testing skills for electrical and electronic components will be crucial for ensuring functionality and safety, while specialized skills in data analytics, vehicle testing, and diagnostics will also become increasingly important.

For example, industry participants from Pune indicated a preference for diversifying into power electronics, given the growing EV and EV component manufacturing ecosystem in the region. Those in Nashik preferred focusing on EV charging equipment manufacturing considering their expertise in electrical components, whereas stakeholders in Kolhapur highlighted motor and transmission systems, given their strength in foundry and engineering. To support these diversification efforts, participants emphasized the need for multifaceted skills on their production floor, and specifically, skill set development in the assembly and testing of different EV components that they were interested in diversifying to. For example, firms diversifying into power electronics would require training in printed circuit board (PCB) design and assembly and automated optical inspection. Firms exploring EV charging infrastructure would need skills in power electronics, PCB design and assembly, power load management, thermal management systems, and harness assembly. Similarly, for firms in Kolhapur looking to transition to EV motor and transmission systems, training in stator and rotor assembly, including coil winding techniques, would be needed. Additionally, they stressed on skill development in the design aspects of these components for white-collar roles to drive R&D and innovation.

Given the industry's considerable skill requirements, firms are ramping up their in-house training programs to provide adequate on-the-job training for new and existing workers. Simultaneously, larger manufacturers are collaborating with industry associations and vocational training institutions to develop joint skill training initiatives, as mentioned by experts from a leading auto OEM. However, such initiatives are not widespread across all clusters. For instance, while the Pune cluster already has some skill-development initiatives underway, Kolhapur is still in the planning stage, and stakeholders in Nashik are seeking EV labs to provide hands-on training to students aspiring to enter the automotive industry. Further, the availability of trained instructors to deliver these courses is currently limited, which poses a challenge given the growing demand for a skilled EV workforce. Thus, industry stakeholders underscored an urgent need for targeted and cluster-specific skill-development initiatives.

Entry points for action: Workshop attendees, especially representatives from the industry and skill development institutions, called attention to the need for upskilling and/or reskilling ICEV workers and training new entrants in the automotive workforce in relevant EV skills. To meet the growing demand for new skill sets, greater synergy among government, industry, and academia is going to be essential. Designing collaborative industry-oriented courses at the cluster level and updating academic curricula to reflect evolving skill requirements arising from the the EV transition were proposed by the participants. They indicated that skill training institutions, whether academic or vocational, need to work closely with industry to create EV-specific training programs for both new entrants and the existing workforce. Upskilling programs can also accommodate the needs of active workers to avoid wage loss and prevent disruptions to MSME productivity.

Moreover, developing two types of skill-development-related policies were emphasized: policies providing financial support to MSMEs for skill-development initiatives and those incentivizing OEMs/Tier I enterprises to undertake capacity-building activities for workers and suppliers. Such collaborations could facilitate a smoother transition and ensure a skilled workforce ready for an evolving automotive landscape.

Financing support will be instrumental in furthering EV manufacturing initiatives

EV and EV component manufacturing enterprises in India, particularly MSMEs diversifying into the EV supply chain, face significant challenges in securing funding for upgrading manufacturing equipment and facilities, R&D, technology innovation, and associated prototyping, testing, and certification processes.

Affordable financing remains a major hurdle for EV component-manufacturing MSMEs and start-ups. The EV market's dynamic nature necessitates considerable investments in R&D, technological innovation, and infrastructure improvements to stay competitive. However, the risks associated with long-term returns on investments for an evolving technology like EVs deter banks and investors.

Financial institutions' cautious lending policies further complicate the landscape for automotive MSMEs planning to diversify into EV-related manufacturing and for EV start-ups. Currently, the EV sector is not eligible for priority sector lending (PSL), which refers to a framework set by the Reserve Bank of India (RBI) that mandates banks and financial institutions to allocate 40 percent of their net credit to priority sectors. Industry representatives highlighted the need to include the EV sector in these guidelines to facilitate easier credit access.

Entry points for action: Representatives from the industry, especially MSMEs, pointed out that access to finance considerably constrains their business growth. Therefore, industry stakeholders believe it is essential to assess the overall financing needs of their transition to develop targeted solutions. Access to credit at lower interest rates, especially for financially constrained MSMEs and emerging start-ups was proposed by participants for fostering innovation and enabling expansion into new technologies. A progressive policy framework that attracts both domestic and global investment in EV and component manufacturing could help stimulate R&D and innovation. Additionally, introducing credit guarantee schemes tailored to MSMEs in the clean-tech sector can further boost technological innovation.

The workshop participants highlighted that it is equally important to assess how easily MSMEs diversifying into the EV value chain can access existing financing schemes and support measures. Including the EV sector in the RBI's PSL guidelines could incentivize banks to increase lending to this sector. Further, OEMs and Tier I enterprises that have already diversified or plan to diversity into EV manufacturing can also help facilitate access to technology and enable measures that can help suppliers access financing. Industrial policies that incentivize OEMs and Tier I enterprises to set up integrated manufacturing facilities can also help support their MSME suppliers.

A mix of industry initiatives, infrastructure services, and policy support are required to facilitate a seamless transition for MSMEs

The EV transition is creating business expansion opportunities not just for OEMs and large Tier I enterprises but also for their Tier I, II, and III supplier MSMEs, who typically manufacture low-value products. These MSMEs can capitalize on the transition by exploring the production of high-value products, which could help them move up the value chain over time. However, a lack of awareness regarding EV transition, inadequate ecosystem-level services such as requisite infrastructure and policy support, and few suitable initiatives to facilitate technology transfer hinder their progress.

While large, well-established firms are typically up to date regarding technological developments in the automotive industry, often leading such developments themselves or participating in relevant discussions with government and industry stakeholders, their MSME counterparts down the value chain rely on their customers for such information. Industry representatives pointed out that OEMs have not yet provided clear indications to their suppliers regarding changes to their product portfolios, leading to limited demand signals for new or revised components. This issue is more pronounced in relatively less-developed automotive hubs such as Nashik and Kolhapur, where MSMEs' awareness levels are lower due to weaker connections with OEMs and large Tier I enterprises, whose headquarters and manufacturing units are in better-developed hubs like Pune.

OEMs and large Tier I enterprises have an edge in terms of being able to forge partnerships with global players, facilitating technology transfers that spur innovation. If these technology transfers were extended to suppliers down the value chain, the production of India-made EV components could be scaled up. This would help reduce the country's heavy reliance on imports, given the nascent nature of the EV sector. However, MSME suppliers often lack the networks or credibility to access such partnerships, limiting their ability to build specialized technological capabilities and preventing them from leveraging the transition to advance the value chain.

Simultaneously, the lack of basic ecosystem services, including infrastructure and supportive policies, acts as a major barrier for MSMEs in exploring the manufacturing of new technologies. For instance, some MSMEs face high product or component rejection rates owing to increasingly stringent quality requirements, particularly for rapidly evolving EV technologies. This can be attributed to the lack of sufficient testing infrastructure, leading MSMEs to deliver products with minimal or no prior testing. Moreover, frequent power outages disrupt production, preventing them from scaling up production. The lack of affordable land for establishing new manufacturing units compounds these challenges, as MSMEs operate in limited spaces and can expand into new technologies only if access to low-cost land with proper connectivity and basic support infrastructure is available.

Entry points for action: Participants highlighted the importance of introducing automotive MSMEs to the discourse on clean and sustainable transport and encouraging them to learn from manufacturers who have successfully diversified into EV-related sectors. To this end, a platform could be developed to regularly disseminate information on the latest sector developments to ensure the most vulnerable stakeholders can seize potential opportunities while avoiding risks. Large enterprises could also help their suppliers form partnerships with global players to build their design and engineering capabilities.

Industry stakeholders also stressed the need to build a supportive infrastructure ecosystem for MSMEs that includes adequate prototyping and testing facilities, access to affordable land, uninterrupted power supply, and other utilities. This could be facilitated through specific fiscal and non-fiscal incentives in EV policies aimed at MSMEs to help them establish the necessary infrastructure. Additionally, underutilized or defunct plants could be refurbished into EV manufacturing units through attractive refurbishment policies. Tax benefits and interest rate subventions under current schemes and industrial policies could also be enhanced for MSMEs in the EV sector.

The development of shared facilities can substantially contribute to fulfilling the ecosystem-level needs of MSMEs actively exploring EV manufacturing. Notably, the Telangana state government is currently developing India's first dedicated mobility cluster, the Telangana Mobility Valley (TMV). The aim is to develop four mega-clusters of over 3,000 acres in and around Hyderabad as part of the TMV. Each cluster will be equipped with state-of-the-art testing and validation infrastructure to reduce operational costs for companies (Bharadwaj 2023). Another similar initiative in the region is T-works, India's largest prototyping center that offers facilities such as a metal shop, electronics lab, testing lab, PCB fabrication, and laser cutting and engraving (T-Works n.d.).

Innovation hubs and incubation facilities are instrumental to EV start-up growth

As a sunrise sector with high innovation potential, the EV industry is characterized by a large number of start-ups venturing into vehicle and component manufacturing. These start-ups explore business opportunities in innovative or untapped areas with the aim of achieving a sustainable, replicable, and scalable business model (Costa and Carvalho 2022; Widyanto and Haryanto 2021). However, their growth depends on the availability of ecosystem-wide facilities that can sustain their long-term operations.

Particularly during their initial stages, EV start-ups face numerous challenges, including high initial capital investment, technological complexity, product development/testing/certification, supply chain issues, regulatory hurdles, and competition from legacy companies. In this context, innovation hubs and incubation centers can provide critical resources for fledgling start-ups. Incubation centers provide seed or series funding to start-ups through various government schemes and private-sector partners. Further, both innovation hubs and incubation centers provide some or all the following services:

- Technical support, such as expert mentorship, partnerships with industry associations, and skill-development training and workshops.
- Business development support in the form of assistance with prototype development, market access, networking, and access to infrastructure and testing facilities.
- Regulatory and compliance support, including assistance with navigating government finance schemes.
- Intellectual property protection assistance.

Industry representatives pointed out the gaps in incubation support tailored to emerging EV start-ups. For instance, while many incubation centers offer funding opportunities through hackathons, challenges, and other similar avenues, they often use strict eligibility criteria to screen participants. Although these criteria are necessary to streamline funding and ensure proposed products add value to the ecosystem, they may not be conducive for new players trying to enter the market. Moreover, the grant amounts may be insufficient for conducting the requisite R&D for building expertise in new product/component categories. In addition to these gaps, the incubation ecosystem is typically stronger in metropolitan areas such as Mumbai and Pune than in Tier II or III cities like Nashik and Kolhapur.

The lack of labs or research centers promoting technological innovation within educational institutions is another challenge for new EV manufacturing entrepreneurs. Weak networking between industry stakeholders and academic institutions, particularly in peripheral regions of major automotive hubs such as Pune and in relatively less-developed hubs such as Nashik and Kolhapur, exacerbates this issue. Consequently, educational institutions are unaware of technological transitions taking place, leading to little or no investment on their part in infrastructure upgrades to accommodate the industry's evolving needs.

Entry points for action: Representatives from EV start-ups, incubation facilities and skill development institutions highlighted the need for a robust innovation ecosystem in key automotive clusters to support emerging EV start-ups and foster greater start-up activity. Incubators, innovation hubs, and CoEs could be established through collaborations between government, industry, and educational institutions. For example, the Promoting and Accelerating Young and Aspiring Innovators and Startups program within the GoI's Ministry of Science and Technology provides financial support to innovative start-ups as a pre-incubator. At the industry level, initiatives like the ARAI-Advance Mobility Transformation & Innovation Foundation support start-ups and innovators from conceptualization to commercialization. At the state level, the Maharashtra State Innovation Society under the Department of Skills, Employment, Entrepreneurship, and Innovation holds an annual start-up event to encourage innovation, with winning start-ups receiving government work orders.

At the regional level, well-developed automotive clusters like Pune are witnessing the growth of innovation hubs and incubation centers. For example, ACDRI in Pune provides facilities for product development, prototyping, and testing, and the Pimpri-Chinchwad Incubation Centre and the Atal Incubation Centre of the Pinnacle Entrepreneurship Forum offer financial, business development, and technical support. State governments could introduce financial incentives for creating and operating incubation centers, following the example of the Tamil Nadu government.

CoEs could also be established in universities across different clusters to facilitate innovation. For instance, in Kolhapur, L&T EduTech partnered with the Tatyasaheb Kore Institute of Engineering and Technology (TKIET), to start an exclusive CoE for spearheading innovation in the EV industry. TKIET also plans to introduce several EV-specific courses as part of its existing curriculum.

Along with the creation of new facilities, workshop participants emphasized the need to raise awareness regarding the incubation and innovation avenues available at the local, state, and national levels among existing manufacturers and new start-ups to help them take advantage of these opportunities.

Comprehensive policy interventions are required to sustain the EV transition

Amid India's evolving automotive landscape, robust policies and regulatory frameworks are critical for fostering a conducive environment for automotive MSMEs to expand their product portfolios or diversify into the EV sector. To this end, central and state-level government agencies have rolled out multiple policies and schemes providing fiscal and non-fiscal benefits to promote localized manufacturing and job creation. In Maharashtra, these efforts have been streamlined through the state's EV policy (2021), industrial policy (2019), and skill-development policies such as the Pramod Mahajan Grameen Kaushalya Vikas Yojana (2023). Although the government has been taking steps toward developing India as an EV manufacturing hub, auto-component manufacturers from the Pune, Nashik, and Kolhapur clusters have raised the need for a clear medium-to-long-term roadmap for EVs in India to build confidence in the industry. They also highlighted the importance of more comprehensive and industry-oriented (supply-side) measures in EV policies to ensure a seamless transition for manufacturers as the EV sector evolves.

Since India's EV ecosystem is still in its nascent stage, industry stakeholders highlighted several manufacturing areas where domestic competencies are not at par with international products available in the market. High-value components such as EV batteries are not being manufactured in India owing to a lack of raw materials and established supply chains. However, the GoI wants to fast-track localized production of all major EV components to strengthen the resilience of the Indian automotive industry against external competition.

To promote local industries during the EV transition's current phase, the GoI has introduced several subsidy schemes, such as FAME I and II, the Electric Mobility Promotion Scheme 2024, the Phased Manufacturing Programme (PMP), and PLI schemes for Advanced Chemistry Cells manufacturing (PLI-ACC) and the auto and auto-component industry (Press Information Bureau 2024). However, some industry stakeholders argued that decreasing production costs through short-term policies that allow reduction in or exemptions of customs duties for critical EV powertrain components is more pressing, given domestic manufacturing capabilities in India are still limited. Such measures could boost local industries currently dependent on imported components. Furthermore, some stakeholders considered that the eligibility criteria for PLI for automobile and auto component industry or PLI-ACC scheme benefits were difficult for MSMEs to meet. Accordingly, while the industry acknowledges the need for aggressive investment-oriented policies for strengthening domestic manufacturing capacities, it also considers that basic eligibility criteria should be eased to increase their coverage. In the medium-to-long term, this would support a robust domestic supply chain for EV manufacturing, enabling MSMEs to grow and reducing India's import dependence.

Accelerated EV adoption is crucial for attracting investment in and scaling up EV manufacturing in a given region, as it creates proximate demand centers for suppliers to serve. Achieving the 30 percent EV penetration target by 2030 requires strong policy support, including measures to enhance EV cost-competitiveness, develop an extensive and robust charging infrastructure network across cities and highways, and establish a well-supported after-sales market for EV maintenance and repair.

Entry points for action: Industry representatives highlighted the need for state-level roadmaps that outline the short-, medium-, and long-term strategies for promoting EV manufacturing and supporting India's EV targets, as they build industry confidence. It was also recommended that existing schemes should cover a wider range of vehicle segments and manufacturer types to ensure broader industry support. Investment-oriented schemes, such as the recent "Scheme to Promote Manufacturing of Electric Passenger Cars," which allows electric four-wheeler manufacturers to import up to 8,000 completely built-up vehicle units if they establish manufacturing facilities with a minimum investment of INR 4,150 crore, could create business opportunities throughout the supply chain (Press Information Bureau 2024). Stakeholders also suggested that time-bound duty exemptions for critical EV components through schemes like the PMP should be implemented until domestic competencies are developed to ensure the cost-competitiveness of domestically manufactured EVs. The Maharashtra government could also focus on strengthening demand-side measures in its EV policy to indirectly support the manufacturing industry. These policy interventions could be achieved through a comprehensive transition plan developed collaboratively by all relevant Maharashtra government departments.

NEXT STEPS

The awareness workshops convened representatives from the government, industry, and educational institutions to explore strategies for a smooth transition to e-mobility in Maharashtra. The following key measures were recommended by the stakeholders as next steps to address industry challenges:

- Comprehensive cluster transition plans to identify and address the transition needs of firms within each cluster, as well as the socioeconomic risks faced by various automotive clusters due to the technology transition.
- A platform for regular information dissemination on technological developments in the automotive industry among MSMEs (both auto and non-auto sectors), enabling them to leverage new opportunities.
- Appropriate financing mechanisms to promote innovation and enable MSMEs and start-ups to expand into new technologies.
- Cluster-specific skill training initiatives through collaborations between industry stakeholders, academic or vocational training institutes, industry associations, and the state government.
- Awareness and ambition among OEMs/large Tier I auto-component manufacturers to support MSME suppliers in their transition to EV manufacturing.
- Incubation centers and CoEs in universities through collaboration between industry associations, government bodies, and local educational institutions to drive technological innovation.

APPENDIX A
Industry participants

AFECO Heating Systems
Ambar Auto Engineers Pvt. Ltd.
Arni Mech Products Pvt. Ltd.
Ask Group
Bharati-AHS Powertech Pvt. Ltd.
Delta Finochem Pvt. Ltd.
Devise Electronics Pvt. Ltd.
EDS Technologies
eRevo Engineering Pvt. Ltd.
IP Silcones
JCAD Solutions
Mahek Industries
Mangesh Enterprises
Maurya Industries
Menon Bearings
Modern Patterns
MPLG Services Pvt. Ltd.
Nasik Ispat Pvt. Ltd.
Navkar Technologies
Nitsun Solar Energy Pvt. Ltd.
Nova Teckno
Patil Industries
Perfect Industries
Plus Industries
Pushpraj Engineers
Revamp Moto
Revine Technologies Pvt. Ltd.
Rishab Instrument Ltd.
S.B. Reshellers Pvt. Ltd.
SB Enterprises
SCharge Pvt. Ltd.
Shree Gajanan Automobiles
Shree Tech
Slidewell Meilleur Tech Pvt. Ltd.
Solar Arks
Solarplexus Inc
Suchitra Printers
SYM Engineers
T&T Consulting Corporation
TAG Automotive
Tanvi Enterprises
TASPowerTek Ltd.
TDCOB Pvt. Ltd.
Texo Industries
USPI Consulting Pvt. Ltd.
V M Auto Part Pvt. Ltd.
Vishwakarma Precision Tools
Yellow Matrix

APPENDIX B
Non-industry participants

Don Bosco Industrial Training Institute

K.K. Wagh Institute of Engineering Education and Research

Maharashtra State Innovation Society, Government of Maharashtra

New Institute of Technology

Sandip Polytechnic

Skill Development, Employment and Entrepreneurship Department, Government of Maharashtra

APPENDIX C
Expert representatives

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Arindam Lahiri, Chief Executive Officer, Automotive Skill Development Council

Balajee Sridharan, Deputy General Manager, Supply Operations, Ather Energy

Chaitanya Kanuri, Associate Director, Electric Mobility, Sustainable Cities and Transport, WRI India

Dhananjay Bele, President, Nashik Industries and Manufacturers' Association

Jayesh Tope, Founder and Managing Director, Revamp Moto

Kausalya Nandakumar, Chief Operating Officer, Mahindra Electric Automobile Limited

Kaustubh Gosavi, Consultant, Electric Mobility, Sustainable Cities and Transport, WRI India

KC Vora, Chair, Automotive Skill Development Council, Expert Group on EV

Kiran K Vaidya, Managing Director, Auto Cluster Development and Research Institute

Maxson Lewis, Founder and Managing Director, Magenta Mobility

Prashant Girbane, Director General, Maharatta Chamber of Commerce, Industries and Agriculture

Rahul Dhadphale, Head, EV Manufacturing Assembly, Mahindra & Mahindra

Ramakrishna Mulay, General Manager, R&D, Piaggio Vehicles Pvt. Ltd.

Sachin Bhamare, Lead, Quality Assurance, EV Manufacturing, Mahindra & Mahindra

Sachin Tanaji Jadhav, Asst. Commissioner, Skill Development, Employment, and Entrepreneurship Department, Guidance Center

Sanjay K Mali, Asst. Commissioner, Skill Development, Employment and Entrepreneurship Department, Government of Maharashtra

Shivling M Pise, Dean, School of Engineering, Technology and Management, TKEIT

Shubhabrata Ghosh, President, Operations, Battrixx

Sunil Dhadiwal, CEO, Atal Incubation Centre, Pinnacle Entrepreneurship Forum

Sunil Shelke, Managing Director, Kolhapur Autoworks Pvt. Ltd.

Teja Kulkarni, Development in-charge, BESPASK Engineers Pvt. Ltd.

LIST OF ABBREVIATIONS

ACC: Advanced Chemistry Cells

ACDRI: Auto Cluster Development and Research Institute

ARAI: Automotive Research Association of India

CIRT: Central Institute of Road Transport

CoE: Center of Excellence

CoEP: College of Engineering Pune

DC: Direct Current

EV: Electric Vehicle

FAME: Faster Adoption and Manufacturing of Hybrid and Electric Vehicles

GDP: Gross Domestic Product

GoI: Government of India

ICEV: Internal Combustion Engine Vehicle

iFOREST: International Forum for Environment, Sustainability & Technology

IoT: Internet of Things

MSME: Micro, Small, and Medium Enterprises

OEM: Original Equipment Manufacturer

PCB: Printed Circuit Board

PLI: Production Linked Incentive

PMP: Phased Manufacturing Programme

PSL: Priority Sector Lending

R&D: Research and Development

RBI: Reserve Bank of India

TKIET: Tatyasaheb Kore Institute of Engineering and Technology

TMV: Telangana Mobility Valley

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