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REPORT

US automotive manufacturing workers in the transition to battery electric vehicles

An assessment of the impact and opportunities

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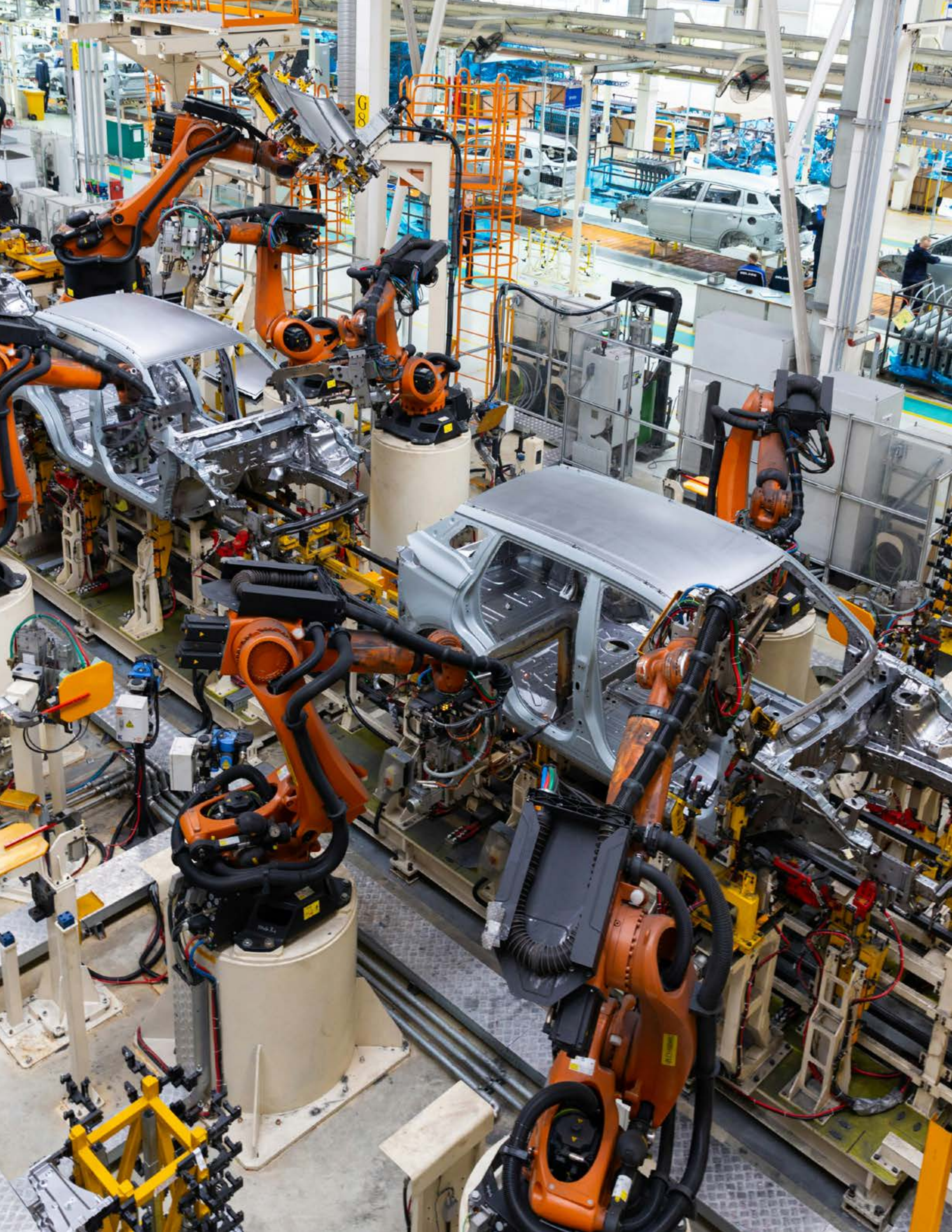
CONTENTS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Foreword

The clean energy transition in the United States is already underway, with no signs of halting. It's a reality taking place in factories, cities, and households across the country. This shift is poised to rewrite the story of one of America's most iconic industries: the automobile. Even in an uncertain policy environment in 2025, Americans have maintained their appetite for battery electric vehicles (BEVs). There were more than 1 million sales of BEVs in the United States in 2023, and sales have only continued to climb, especially as the technology becomes more affordable.

Driven by advancements in battery technology, expanding production volumes, and a global shift toward electrification, BEVs are an increasingly attractive alternative to internal combustion engine vehicles (ICEVs). This shift is not only shaping the future of transportation, but also has profound implications for automotive workers.

The job landscape around vehicle production is changing rapidly. The rise of BEVs is bringing an entirely new supply chain for specific components, alongside new or different roles for technicians, analysts, and engineers. Thousands of jobs have been added for battery technology alone. Yet, BEV systems—involving a battery, inverter, and one or more electric motors—are mechanically less complex than those of ICEVs, which have hundreds of moving parts.

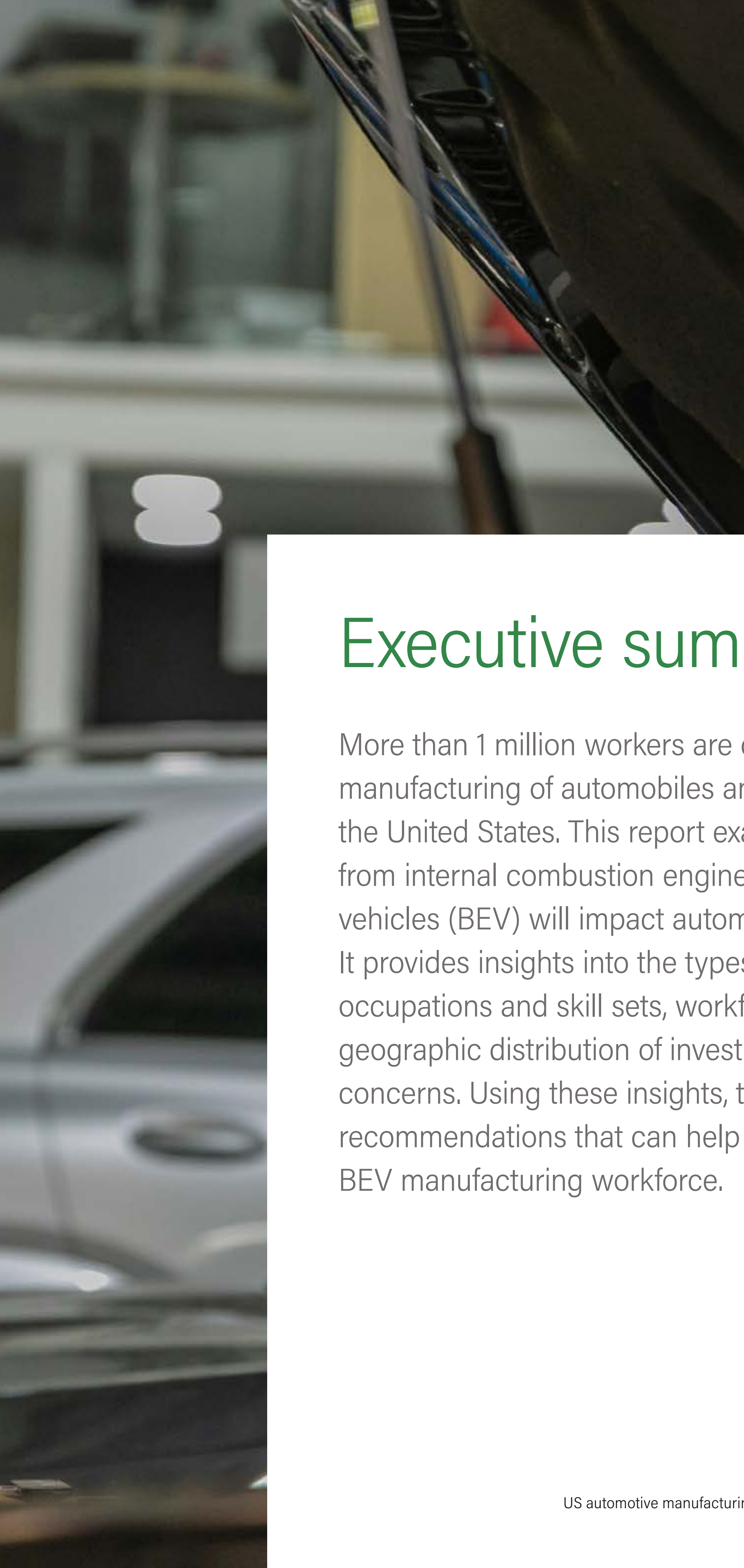
Any major technological shift like this risks leaving people behind. Demand is expected to drop for workers who produce gasoline engines, exhaust systems, and other similar parts. Automation and artificial intelligence are only exacerbating these challenges. If this systemic shift from ICEVS to BEVs is not managed correctly, those currently working in ICEV production face displacement.

There is growing awareness of the transition's impact on US automotive workers, but critical questions remain unanswered: What are the vulnerable occupations? What new skills will be in demand? And what transition pathways exist for workers? Other workforce considerations, such as job quality and the geography of these jobs, have also been left unexamined.

This report attempts to fill data gaps and answer these questions. The BEV industry can only ensure its burgeoning workforce is made up of high-quality, equitable jobs with specific reskilling efforts. Any expansion of BEV manufacturing beyond traditional automaking hubs will also transform the workforce, requiring careful consideration of both the challenges and opportunities of improving job quality and bringing workers of diverse backgrounds into the industry. The report identifies policies and investments that will help ensure all Americans reap benefits from the transition.

Automotive workers have long been a backbone of the American economy, and the clean energy transition will not be successful if they are left behind. The United States has a unique opportunity to ensure a smooth transition that creates new opportunities for its workers—and the time to make these investments is now.

ANI DASGUPTA
President & CEO
World Resources Institute



Executive summary

More than 1 million workers are directly involved in the manufacturing of automobiles and automotive parts across the United States. This report examines how the transition from internal combustion engine vehicles to battery electric vehicles (BEV) will impact automotive manufacturing jobs. It provides insights into the types of at-risk and in-demand occupations and skill sets, workforce training needs, geographic distribution of investment and jobs, and job quality concerns. Using these insights, the report presents different recommendations that can help develop a diverse and skilled BEV manufacturing workforce.

HIGHLIGHTS

- The transition from internal combustion engine vehicles (ICEVs) to battery electric vehicles (BEVs) will likely affect a large majority of the current ICEV manufacturing workforce.
- Workers in gasoline engine and engine parts manufacturing, representing 7 percent of workers in original equipment manufacturers (OEMs) and Tier 1 industries (companies that provide parts to OEMs), are likely to face **significant disruption**. Proactive reskilling efforts can enable even the most vulnerable workers to transition to growing opportunities within BEV manufacturing and adjacent industries requiring similar skill sets.
- Approximately 65 percent of workers in OEM and Tier 1 facilities will likely face **moderate disruption** as components and manufacturing processes evolve, necessitating intentional upskilling efforts.
- The transition will require BEV-specific training programs, including those focused on high-voltage safety and battery manufacturing processes, along with workers trained in advanced manufacturing processes and digital technologies.
- Expanding BEV manufacturing beyond traditional hubs to new states will significantly impact the demand for skilled labor, job quality concerns, worker relocation, and the need for workforce training programs.
- The growing demand for workers presents an opportunity to bring workers of diverse backgrounds into the BEV industry. Intentional efforts to improve wages, benefits, and working conditions can enhance job quality.

Context

For electric vehicle (EV) sales, including BEVs and plug-in hybrid electric vehicles (PHEVs), 2024 was a record-breaking year. In the United States, the world's second-largest auto market after China, EV sales accounted for 10 percent of new car sales in 2024, a twofold increase compared to 2021 (IEA 2025a). Bolstered by the Inflation Reduction Act (2022), the Bipartisan Infrastructure Law (2021), and other federal policies, the United States has seen a boom in EV and battery manufacturing investment. However, the EV transition in the United States is currently facing headwinds. Changes brought by the One Big Beautiful Bill Act (2025), coupled with tariffs and the potential weakening of automotive emissions standards, have introduced considerable uncertainty for the EV industry. Yet although federal policies will impact the pace of the BEV transition, technological advancements, market forces, automaker commitment, and state and local government policies suggest a lasting transformation is under way. The future of US passenger cars is electric!

At the heart of the transition from ICEVs to BEVs are workers who build various vehicle components and assemble them into final products. More than 1 million workers are directly involved with the manufacturing of automobiles or automotive supplies across the United States (BLS 2023d). The ICEV-to-BEV transition is likely to be more disruptive than transitioning from ICEVs to PHEVs due to the degree of change required in workforce skills and the supply chain for BEV manufacturing. In contrast, PHEVs incorporate many traditional ICEV components, making them a more incremental step in the transition. Furthermore, BEVs have been dominant in sales compared to PHEVs, making the ICEV-to-BEV transition a more disruptive undertaking for the automotive industry.

Therefore, it is important to understand how the BEV transition will impact automotive manufacturing workers and the industry. In particular, insights into the types of at-risk and in-demand occupations and skill sets, workforce training needs, geographic distribution of investment and jobs, and job quality concerns can help identify strategies needed to develop a diverse and skilled talent pipeline for the BEV industry.

About this report

This report attempts to explain how the growth of BEV manufacturing will impact automotive manufacturing jobs in the United States.[1] Industries in BEV manufacturing include those producing batteries, electric motors, drivetrains, vehicle bodies, and other essential components, followed by their assembly into a complete vehicle. This report's analysis focuses on answering the following questions:

- What types of automotive manufacturing occupations are at risk of disruption, and what transition pathways exist for workers in those occupations?
- What new occupations and skills associated with BEV manufacturing will be in demand?
- How will the BEV transition influence key workforce considerations, such as job quality, geography of jobs, and workforce inclusivity and diversity?
- How can key stakeholders, including industry employers, state officials, labor organizations, and training and education providers, build an opportunity-rich BEV industry that leaves no worker behind?

Research methods for this analysis include a literature review, secondary data analysis, a national survey of auto manufacturing firms, key stakeholder interviews, and feedback from a nine-member advisory council comprising a diverse group of industry experts and stakeholders. Key findings identify the types of automotive manufacturing occupations that are most likely to face disruption as well as the types of BEV manufacturing-focused occupations and skills that will be in demand. The report also discusses other important workforce considerations, such as the geographic implications of BEV industry trends, job quality concerns, and workforce training needs. Using these key findings, the report presents different recommendations that can help develop a diverse and skilled BEV manufacturing workforce.

Findings

As of the third quarter of 2023, OEMs and Tier 1 industries employed more than 883,000 workers. An additional 196,700 workers were employed in Tier 2 (suppliers providing subcomponents or parts to Tier 1 companies) and Tier 3 (suppliers providing raw materials and individual parts to Tier 2 companies) industries. Automotive manufacturing jobs are heavily concentrated in the Midwest and the South, with over 50 percent of OEM and Tier 1 employment concentrated in five states: Michigan, Ohio, Indiana, Tennessee, and Kentucky. These states, located in the traditional automotive heartland, are key places experiencing the transition from ICEV to BEV manufacturing.

This analysis focuses on workers employed in OEMs and Tier 1 industries. These workers will likely experience more disruption than workers in Tier 2 and Tier 3 industries because the impact filters down through the supply chain. OEMs and Tier 1 industries in the automotive supply chain are categorized by their risk of disruption (Table ES-1):

- **Significant disruption** (due to manufacturing activity specific to ICEVs; e.g., gasoline engine manufacturing). *Significant disruption* would entail greater effort to reskill or adapt and may even pose a threat of the occupation disappearing.
- **Moderate disruption** (due to some differences in manufacturing processes for ICEVs and BEVs; e.g., braking systems manufacturing). *Moderate disruption* would involve learning some new tasks. In this scenario, workers are more likely to easily transition with upskilling efforts.
- **Minimal disruption** (due to minor or no differences in manufacturing processes for ICEVs and BEVs; e.g., car interiors and steering systems). *Minimal disruption* would entail comparatively fewer new tasks and learnings, and work would remain largely unchanged.

The US automotive industry, in parallel with the global automotive industry, is going through significant changes, many of which are directly or indirectly accelerated by the BEV transition. These include the following:

- **A movement toward vertical integration.** Automakers are moving vehicle component production (e.g., battery, motors) in-house to have more control over the supply chain, retain larger profit margins, facilitate integrated component design and vehicle assembly, and protect intellectual property (Isenstadt and Slowik 2023; Saha et al. 2024a).
- **An increasing use of automation and artificial intelligence.** These technologies are transforming the car production process, whether for manufacturing ICEVs or BEVs. The transition to BEVs presents optimal opportunities for manufacturers to simultaneously implement upgrades in production and automation technologies.

TABLE ES-1 | Classification of OEMs and Tier 1 automotive manufacturing industries by risk of disruption from the BEV transition

SIGNIFICANT DISRUPTION (due to manufacturing activity being specific to ICEVs)	**MODERATE DISRUPTION** (due to some differences in manufacturing processes for ICEVs and BEVs)	**MINIMAL DISRUPTION** (due to minor or no differences in manufacturing processes for ICEVs and BEVs)
▪ 336310: Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	▪ 336320: Motor Vehicle Electrical and Electronic Equipment Manufacturing ▪ 336340: Motor Vehicle Brake System Manufacturing ▪ 336110: Automobile and Light Duty Motor Vehicle Manufacturing ▪ 336390: Other Motor Vehicle Parts Manufacturing[a] ▪ 336350: Motor Vehicle Transmission and Power Train Parts Manufacturing	▪ 336330: Motor Vehicle Steering and Suspension Components ▪ 336360: Motor Vehicle Seating and Interior Trim Manufacturing ▪ 336370: Motor Vehicle Metal Stamping ▪ 336211: Motor Vehicle Body Manufacturing

Notes: The table classifies available North American Industry Classification System (NAICS) codes that depict different industries in automotive manufacturing. BEV = battery electric vehicle; ICEV = internal combustion engine vehicle; [a] Exhaust system manufacturing is captured in NAICS 336390, which covers a wide range of vehicle components (including air bags, air conditioners, radiators, air filters, engine exhaust, etc.). There are no exhaust systems in BEVs, and this segment of automotive manufacturing will face significant disruption. Due to this report's inability to separate out industries that exclusively focus on ICEV-specific parts, such as exhaust systems, it has classified NAICS 336390 under the "moderate disruption" category due to the wide range of components this NAICS code covers (including fuel-agnostic components).

Source: Authors, using BLS 2023d and US Census Bureau 2025.

These trends have major implications for worker skills in automotive manufacturing, necessitating a shift toward a new set of capabilities that are responsive to changes brought by multiple intersecting trends.

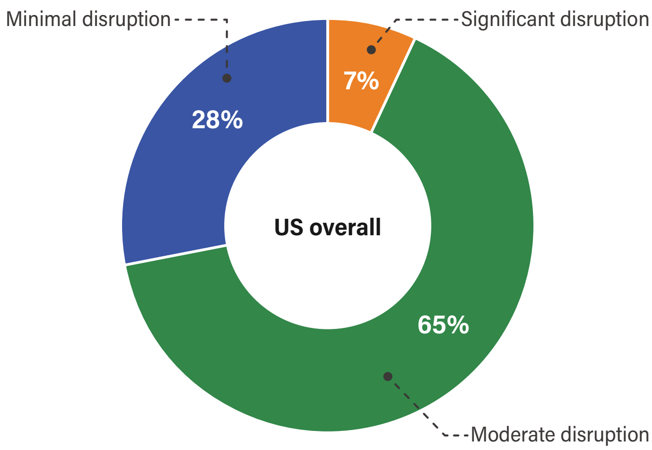
The transition to BEVs will require robust workforce and training programs to support its growth because the differences between ICEVs and BEVs will impact automotive manufacturing processes. Whereas some occupations and roles related to ICEV manufacturing will see declining demand, new skill sets in growing parts of BEV manufacturing will be highly sought-after. All these shifts will require upskilling and reskilling existing workers and training new entrants into BEV manufacturing. The detailed findings from this analysis are listed below.

A small subset of workers within OEMs and Tier 1 industries will likely face *significant disruption*, but there are transition opportunities even for the most vulnerable occupations. This analysis identifies particular industries and workers that are most at risk of disruption or displacement through the BEV transition and examines the transition pathways for those workers.

- **Workers in gasoline engine and engine parts manufacturing will see the most disruption or a decline in demand for their work.** About 7 percent of the workers in OEMs and Tier 1 industries are in gasoline engine and engine parts manufacturing (NAICS 336310), which is the industry likely to see the most volatility because the components that it manufactures are very specific to ICEVs. Moderate impacts are likely within industries that compose 65 percent of OEM and Tier 1 employment as components and manufacturing processes undergo changes from the status quo; these industries will likely not face widespread disruption to their product lines or processes (Figure ES-1). Regardless of whether an industry faces moderate or significant impacts, investments in upskilling and reskilling efforts are necessary to transition workers from ICEV to BEV manufacturing.

- **Although some occupations within gasoline engine and engine parts manufacturing are likely to face declining demand, other occupations are likely to see increasing demand arising from growth in BEV manufacturing and adjacent industries.** Occupations such as engine and machine assemblers are most at risk or vulnerable because these occupations are projected to see economy-wide decline in employment over the next 10 years, offering few transition opportunities for workers in vulnerable occupations in gasoline engine and engine parts manufacturing in the rest of the economy. In contrast, different engineering occupations and electrical, electronic, and electromechanical equipment assemblers are projected to see strong demand growth in other parts of the economy. These include industries related to battery production, electronics, software, and data management, which will increasingly play a prominent role as the

FIGURE ES-1 | Share of employment within OEMs and Tier 1 automotive industry by risk of workforce disruption



Note: OEM = original equipment manufacturer.
Source: Authors, using BLS 2023d and US Census Bureau 2025.

transition from ICEVs to BEVs takes place. The battery manufacturing industry, in particular, can play an increasingly important role in offering transition pathways for workers in vulnerable occupations in gasoline engine and engine parts manufacturing.

- **The wages of workers in vulnerable occupations in gasoline engine and engine parts manufacturing could be higher if they transition to new occupations with similar knowledge, skills, and abilities (KSAs) in battery manufacturing and adjacent industries.** For instance, team assemblers, a vulnerable occupation in gasoline engine and engine parts manufacturing, require similar KSAs as electrical, electronic, and electromechanical equipment assemblers, which is an occupation that is estimated to see increasing demand and offers higher wages. Wages for new occupations might be higher in battery manufacturing and adjacent industries; these industries face a shortage of skilled workers, so employers may be incentivized to offer higher wages. The new occupations might also require more specialized technical skills, which could be a factor contributing to higher wages.

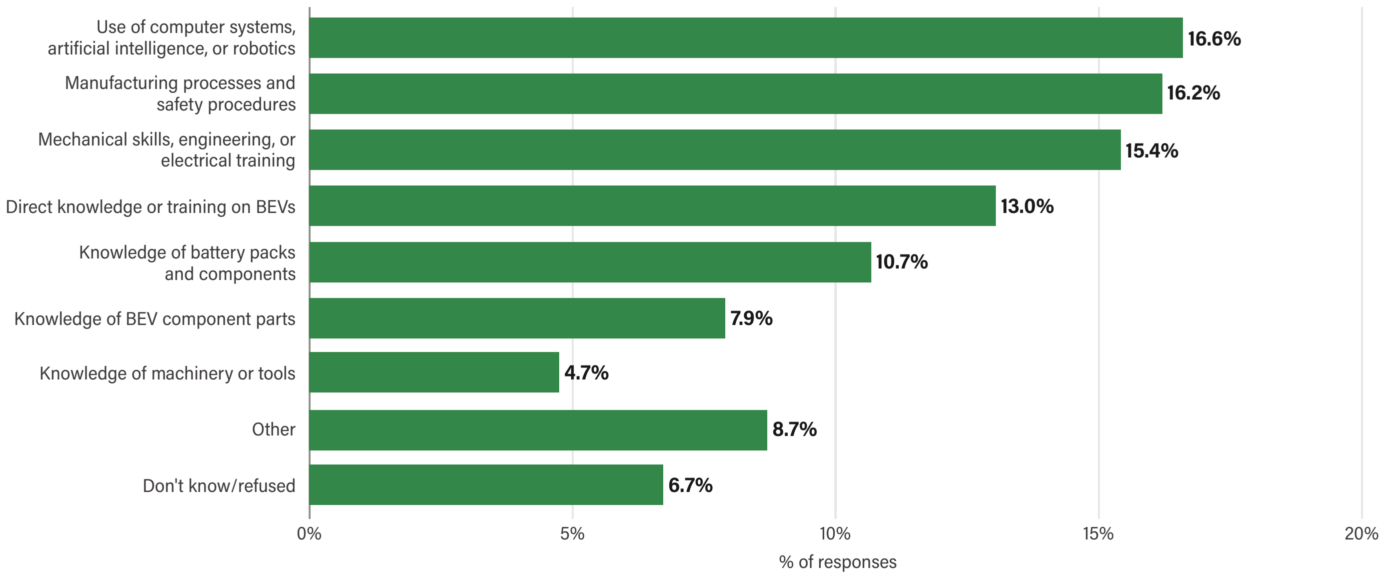
The BEV transition will increasingly require new digital, advanced manufacturing, and specialized skills. Most additional knowledge needed falls into two categories: BEV-specific knowledge regarding high-voltage safety and battery manufacturing processes and the ability to manage increasingly automated manufacturing processes that are often introduced while factories upgrade or adjust production lines and processes for production of BEVs.

- **Major differences in KSAs between BEV and ICEV manufacturing roles are found in electric motor assembly, battery assembly, and thermal management systems.** This means that, even though opportunities exist to transition workers engaged in the most vulnerable occupations in ICEV manufacturing to newer roles within BEV manufacturing and adjacent industries, transitions for workers may be difficult without additional efforts from employers, government, and other stakeholders. Substantial investments in upskilling and reskilling are needed, moving from mechanical-focused skills to a new curriculum centered on electrical, chemical, and software-based systems and an increased focus on safety protocols for high-voltage systems and chemical handling of batteries.

- **The need for knowledge of automated processes and systems goes together with the need for BEV-specific knowledge.** Automation is significantly impacting automotive manufacturing, and the BEV transition is accelerating the adoption of automation due to the requirement of new manufacturing processes, such as battery assembly and electric motor manufacturing. The automotive manufacturing firms surveyed identified that, in addition to knowledge specific to BEVs and engineering or manufacturing best practices, those currently working with ICEVs commonly needed reskilling to learn new computer or robotics systems (Figure ES-2).

- **There is significant need to ramp up and spread training programs in response to the automotive industry's transition to BEVs.** Less than half (47.6 percent) of automotive manufacturing firms that responded to the survey directly offer training programs to both incumbent and prospective workers (Figure ES-3, panel a). Among these firms, over half (57.8 percent) offer on-the-job training programs, and 16.9 percent offer internships, apprenticeships, or boot camps (Figure ES-3, panel b). Additionally, only one in four respondent firms (24.8 percent) in a follow-up survey question reported that they have established formal partnerships with state agencies, local training providers, or educational institutions to address their workforce training needs.

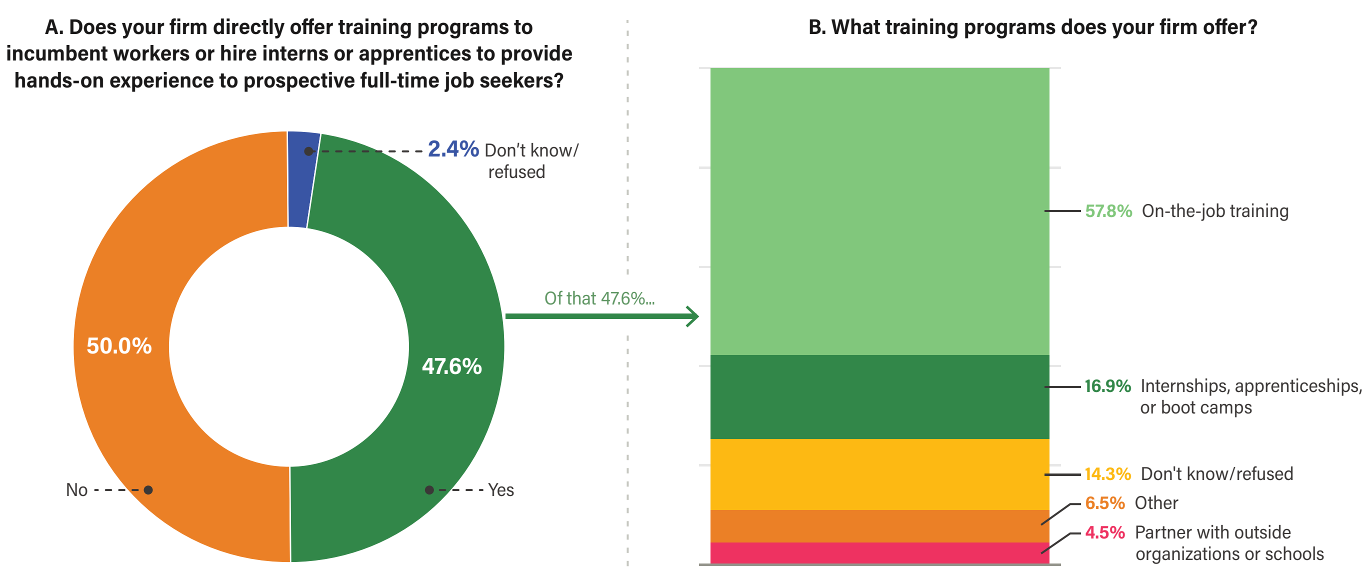
FIGURE ES-2 | What types of new BEV-specific knowledge or skills are required?



Notes: N (number of responses) = 253. BEV = battery electric vehicle.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for BEVs, BEV battery packs or materials, and BEV charging stations.

FIGURE ES-3 | How are automotive manufacturers providing workforce training programs?



Note: N (number of responses) = 330 (panel a), 154 (panel b).

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

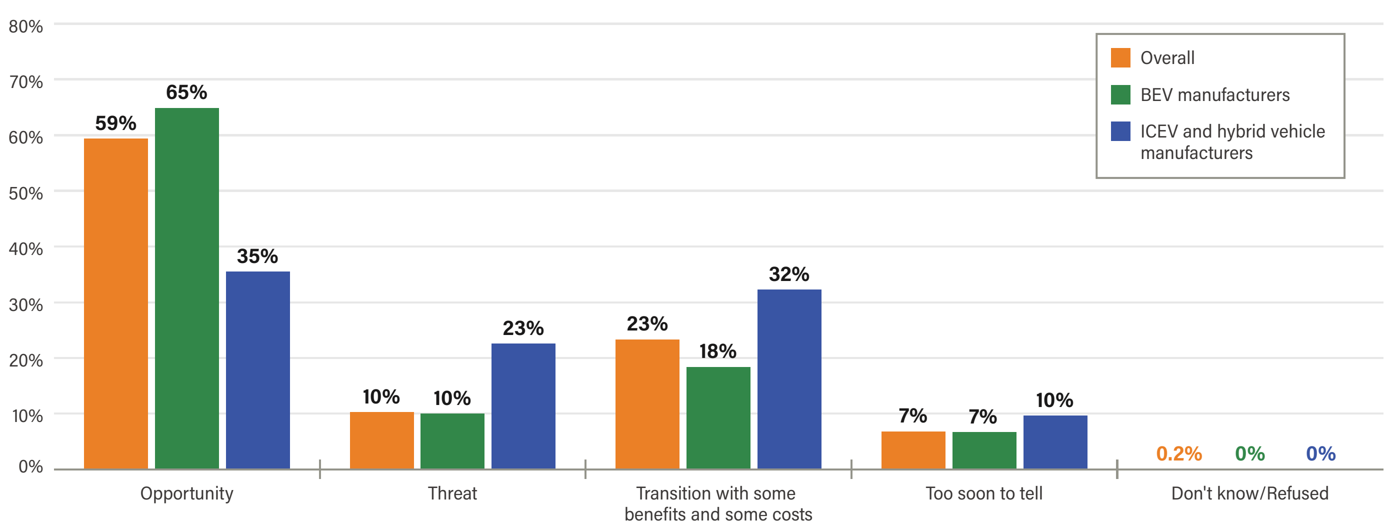
The BEV transition is mostly seen as an opportunity, though manufacturers see some downsides as well. The report's survey was conducted during the first half of 2024, before President Trump took office and the enactment of the One Big Beautiful Bill Act. With that said, the survey indicated that the BEV transition is rarely seen purely as an opportunity or as a threat. The industry has been growing, and most manufacturers were optimistic about future growth, particularly among firms already offering BEV or charger product lines. Employers seem to think about the transition as a reallocation of workers and resources rather than an outright displacement.

- **The rise of BEVs is mostly seen as an opportunity.** Over half (59 percent) of the automotive manufacturers surveyed see the transition to BEVs as an opportunity. Only 1 in 10 (10 percent) identified the transition as a "threat," and approximately 1 in 4 (23 percent) stated there would be trade-offs (Figure ES-4).
- **While most manufacturers expect to grow over the next three years, BEV manufacturing firms were more likely to report expansion in production capacities.** Nearly 2 in 3 (63 percent) manufacturers of BEV products indicated that their firm was expanding capacity at existing locations, and approximately half (46 percent) indicated their firm was adding entirely new manufacturing locations. In contrast, ICEV and hybrid vehicle manufacturers reported lower rates of expansion at their firms compared to BEV manufacturers.

BEV manufacturing is occurring in both traditional automotive hubs and new manufacturing locations, creating a need for transition strategies and training programs based on different historical and geographic contexts. Depending on a region's historical involvement with the automotive manufacturing industry, workers may face difficult decisions about their own career transitions, requiring tailored strategies to support them. Geographic differences will have notable impacts for transitioning workers, primarily in compensation rates and training program availability.

- **There is a geographic mismatch between where vulnerable workers in ICEV manufacturing are currently working and where new jobs in BEV manufacturing are emerging.** Transitioning to BEV manufacturing for workers within the same factory, county, or even state may not present a challenge, but workers in some states might not have an offsetting opportunity within the industry. Workers in gasoline engine and engine parts manufacturing, in particular, may face such geographic challenges. Even if there are other offsetting BEV manufacturing opportunities, those opportunities may require relocation alongside investments in reskilling efforts.

FIGURE ES-4 | Automotive industry perspectives of the BEV transition



Note: N (number of responses) = 330. BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for BEVs, BEV battery packs or materials, and BEV charging stations.

- **Wage differences within the same occupations across different states can pose transition challenges for displaced or at-risk automotive manufacturing workers if they have to relocate; instead, the focus needs to be on retraining these workers for in-demand occupations in BEV manufacturing and adjacent industries.** Providing displaced or at-risk automotive manufacturing workers with retraining in high-demand occupations in BEV manufacturing, such as manufacturing batteries and electronics for BEVs, can increase the earning potential of these workers and make them more attractive to employers. Robust federal programs and cross-state partnerships, however, will be needed to provide retraining for workers shifting to BEV manufacturing in different locations.

The BEV transition presents an opportunity to improve job quality and opportunity for all. While the BEV transition has prompted concerns about job quality and union negotiating power, it also creates potential for inclusive opportunities in automotive manufacturing. Accelerated automation can have both benefits and challenges for job quality. Automation can minimize worker exposure to dangerous tasks and lead to the creation of higher-skilled roles that offer greater wages and benefits. However, automation could also drive worker displacement and expose workers to new types of safety risks.

- **The need to hire new workers into the industry presents an opportunity to bring more workers of all backgrounds into the industry.** Roughly a quarter of the current automotive manufacturing workforce could retire over the next 10 years (BLS 2023a). As different parts of the BEV supply chain grow in the United States, the industry will provide job opportunities to hire workers from different backgrounds, including women, who currently account for 33 percent of workers within the top automotive industry occupations while making up roughly half of the US labor force (BLS 2023a). Black workers and workers with less than a bachelor's degree also stand to gain from an expansion of the BEV industry given their higher participation in automotive manufacturing compared to the rest of the economy. However, building a diverse talent pipeline will not happen on its own without intentional policies.
- **Concerns regarding job quality and union negotiating power persist as the ICEV-to-BEV transition happens.** Jobs in automotive manufacturing were once a ticket to the middle class in America, offering family-sustaining wages and benefits. However, automotive manufacturing workers have seen a significant decline in wages, working conditions, and bargaining power in the last few decades due to multiple factors, including offshoring, economic shocks, temporary or contract labor, and rising automation (Barrett and Bivens 2021; Saha et al. 2024a). The transition to BEVs can reinforce these regional patterns, especially since a significant portion of new investments in BEV manufacturing is going to southern states, which have right-to-work laws that make it difficult for workers to form unions and collectively bargain for better pay and working conditions (Chava et al. 2020; Childers 2024).
- **Occupations that are more likely to grow as the industry automates offer higher wages than their corresponding incumbent occupations.** This finding means that workers who are able to upskill and work with automation technologies at a greater capacity may be better off with new, higher-quality jobs. However, lower demand for workers overall means that additional support to find opportunities in related occupations within automotive manufacturing or adjacent industries will be necessary for workers who are not able to directly transfer to these more automation-oriented positions.

Policy recommendations

The BEV transition presents key stakeholders—businesses, government, educational and training institutions, labor unions, and others—with an opportunity to maximize the benefits and minimize the challenges for automotive manufacturing workers. Focused, collaborative, and intentional efforts for workforce development are necessary for both workers and the industry to grow and thrive. The recommendations highlighted in Figure ES-5 speak to both the need for upskilling and reskilling workers currently engaged in manufacturing ICEV-specific power train components and for developing the new workforce to meet the emerging opportunities in BEV manufacturing. These recommendations can be adopted at the state and local levels, with state and local governments uniquely positioned to understand regional needs and create pathways for workers in BEV manufacturing. With the federal government pulling back support for clean technologies such as EVs through spending cuts and policy changes, the focus now shifts to leveraging nonfederal resources.

FIGURE ES-5 | Summary of policies to help develop a diverse and skilled BEV manufacturing workforce

RECOMMENDATION CATEGORY	RECOMMENDATION	RELEVANT STAKEHOLDERS			
		Government	Education	Industry	Civil society
Addressing disruptions for the most vulnerable occupations	Tailor transition support and policies to specific groups of workers most likely to be impacted by the transition (for example, assemblers working within gasoline engine and engine parts manufacturing).	X	X	X	
	Develop rapid response capabilities to address automotive facility closures.	X		X	
	Emphasize state and local economic development and workforce development agency collaboration.	X			
	Prioritize the development of local economic and workforce development initiatives to support new industries in regions that are most prone to acute plant closures (such as engine component manufacturers).	X	X	X	X
	Focus on midcareer training programs and upskilling programs that help existing workers address gaps in their knowledge and skills for new technologies associated with BEVs or more automated manufacturing processes.	X	X	X	
Training workers for new digital, advanced manufacturing, and specialized skills	Tailor training programs to focus on fundamental math, basic mechanical systems, data literacy, and systems thinking coursework.	X	X	X	
	Develop shared industry resources to strengthen upskilling and training offerings.		X	X	
	Create a standardized training curriculum that can be used to support training providers to develop new training programs in geographies with burgeoning BEV manufacturing.	X	X	X	
Reducing risks and uncertainty for BEV manufacturers	Continue to send strong market signals to industry and support consumer adoption where possible.	X			X
	Consider offering state- or local-level conversion grants or loan guarantees to upgrade and retain existing manufacturing locations.	X			
	Proactively monitor and support the BEV industry to address external volatilities in the industry.	X			
Investing in workforce development and training programs that are tailored to specific needs within a state	Assess state-specific workforce needs and tailor training programs to meet those needs (legacy automotive manufacturing states will require different training curriculum support than those developing an automotive manufacturing ecosystem from scratch).	X	X	X	
	Prioritize supporting the expansion of, and access to, established training programs with a proven record of success before creating entirely new programs to avoid duplicative efforts.	X	X	X	
Improve job quality and opportunities for all	Support pre-apprenticeships, apprenticeships, and on-the-job training for workers.	X	X	X	X
	Build awareness of career and opportunities in the BEV industry, prioritizing awareness of high-demand BEV occupations	X	X	X	X
	Create partnerships to engage groups that may have unique barriers to entering or reentering the workforce.	X	X	X	X
	Explore tiered incentives for manufacturers based on job quality standards.	X		X	

Notes: "Government" includes state labor/workforce departments, state economic development departments, and local governments. "Education" includes universities, community colleges, technical/vocational schools, and middle and high schools. "Industry" includes employers and industry associations. "Civil society" includes labor unions, nonprofit organizations, and advocacy and research organizations. BEV = battery electric vehicle.

Source: Authors.

Introduction

The shift toward BEV manufacturing necessitates significant changes in the automotive workforce, requiring new skills and training to handle the specialized technologies and manufacturing processes involved. Workers involved in manufacturing ICEV-specific power train components are likely to face the greatest relative disruption while new positions in battery and power electronics manufacturing will emerge. Education and training, upskilling, and reskilling initiatives are imperative to equip workers with the competencies to thrive in a new, electrified manufacturing environment. The analysis and recommendations presented in this report can help ensure that the BEV transition enables workers and employers in automotive manufacturing to reap the benefits and opportunities presented by the transition.

The transportation sector is undergoing the largest transition in over a century, with the global sale of battery electric vehicles (BEVs) expected to outstrip internal combustion engine vehicles (ICEVs) in the coming years.[2] In the United States, sales are still growing, but recent federal policy changes have the potential to slow the country's adoption of BEVs. Over the longer term, however, BEVs will continue to take more market share. As global and US demand for BEVs grow, so will the demand for jobs in BEV manufacturing. From assembly-line workers to battery manufacturing specialists, analysts expect new job opportunities in a rapidly developing part of the automotive industry.

For electric vehicle (EV) sales, 2024 was a record-breaking year. Global sales of EVs, including BEVs and plug-in hybrid electric vehicles (PHEVs) surpassed 17 million, accounting for 22 percent of all cars sold worldwide and increasing from 14 million, or 18 percent, of car sales in 2023 (IEA 2025a). BloombergNEF (BNEF) also marks 2024 as a record year for EV sales with over 17 million electric car sales and expects EVs to make up 26 percent of car sales in 2025 (McKerracher et al. 2025).

In the United States, the world's second-largest auto market after China, EV sales accounted for 10 percent of new car sales in 2024, a twofold increase compared to 2021 (IEA 2025a). The International Energy Agency (IEA) expects EVs to account for 21 percent of US car sales by 2030, whereas BNEF projects this at 27 percent by 2030, down from its 2024 estimation of 48 percent sales share by 2030 (IEA 2025a; McKerracher et al. 2025; Walton 2025). Although both the IEA and the BNEF EV market outlooks have started to account for emerging policy and trade uncertainties in longer-term sales projections, they still expect EV adoption to at least double by 2030, compared to 2024 levels.

Exploring the impacts and benefits of the BEV transition

The focus of this report is to explore the impacts of the ICEV-to-BEV transition on US automotive manufacturing workers. This transition is likely to be more disruptive than transitioning from ICEVs to PHEVs due to the degree of change required in workforce skills and the supply chain for BEV manufacturing. Furthermore, BEVs have been dominant in sales compared to PHEVs, making the ICEV-to-BEV transition a more disruptive undertaking for the automotive industry.

Despite the uncertainty posed by the Trump administration's policies and the negativity surrounding the US BEV industry as of late, the authors believe that the future of US passenger cars is fully electric. Understanding how the transition from ICEVs to BEVs impacts the automotive manufacturing workforce is therefore critical and the motivation for this report.

On his first day in office, President Donald Trump revoked an executive order signed by former President Joe Biden in 2021 aimed at making 50 percent of US vehicle sales electric or zero emission by 2030. He also announced his intention to roll back vehicle emissions standards and eliminate tax credits and other climate policies. The passage of the One Big Beautiful Bill in July 2025 brought significant changes to the EV industry by modifying, phasing out, or repealing several tax credits established under the Inflation Reduction Act (IRA). These include eliminating the federal tax credit for purchasing new and used EVs after September 30, 2025; phasing out the federal 30C alternative fuel vehicle refueling property credit that covers EV charging equipment by June 30, 2026; and modifying the Section 45X advanced manufacturing production credit for EV batteries and critical minerals that will influence the cost and viability of domestic battery and critical minerals production. In June 2025, California's long-standing authority to set its own, stricter emissions standards under the Clean Air Act was revoked. It is currently being challenged by California and other states.

While the EV industry will continue to face headwinds under the Trump administration, the authors believe that a combination of factors will keep the transition going in the United States amid these challenges. These include favorable policies at the state and local level (including demand-side consumer subsidies for purchase and leasing and supply-side subsidies for batteries, plant conversion, and EV chargers); sustained consumer appetite; and advances in EV technology that make EVs cheaper, more efficient, and more convenient for consumers.

The transition to BEVs presents tremendous benefits and opportunities to the US consumer, economy, and climate. Life cycle emissions—total emissions produced during a vehicle's production, operation, and disposal—for BEVs are considerably lower than for gasoline cars (Buberger et al. 2022). BEV owners, across every major type of vehicle except pickup trucks, save thousands of dollars over a seven-year lifespan relative to owners of comparable gas-powered cars (Wilkins and Nigro 2025). In addition, EV batteries can potentially be

used as a power source for homes, buildings, and the power grid through a set of bidirectional "vehicle-to-everything" charging technologies (Sheja 2024). The BEV industry is also driving job creation and contributing to economic growth in several sectors, including manufacturing, engineering, software development, and infrastructure (Colato and Ice 2023; Cosier 2024).

As countries across Europe and Asia—especially China—set aggressive EV goals and automakers worldwide ramp up EV production in response, the United States cannot afford to be left behind in the race to electrify vehicles. The United States needs to be able to compete in this emerging global market or risk jeopardizing its long-standing automotive leadership. Even the Alliance for Automotive Innovation—which represents 42 automakers, including Ford and General Motors (GM), and advocates for policies that are supportive of the automotive industry—urged the Trump administration to leave the Biden administration's EV regulations and tax credits in place (Davenport and Ewing 2024). At the same time, the Alliance has supported repealing California's waiver that allows the state to set stricter vehicle emissions standards.

By actively participating in the EV transition, the United States can ensure the long-term competitiveness of an industry that has long been a source of economic growth; technological innovation; and high-quality, unionized jobs (Walter et al. 2020).

Concerns for the automotive manufacturing workforce

Despite the opportunities presented by the shift to BEVs, the transition to a successful BEV future will stall without a skilled BEV manufacturing workforce pipeline. Expanding BEV production requires new skills and expertise in areas like battery and electric motor technology, along with adjustments to traditional automotive manufacturing processes and heavy reliance on digital technologies and advanced manufacturing processes. The industry requires a skilled and diverse workforce, necessitating focused workforce development efforts through collaboration between government, businesses, educational institutions, and workforce development programs.

The implications of the BEV transition for automotive manufacturing have become particularly salient in the United States for several reasons. First, concerns have been raised that the shift toward BEVs, with fewer moving parts in the final assembly, poses a threat to automotive manufacturing jobs (Hart 2019). Recent studies have found, however, that BEV manufacturing, which includes the production of batteries and power electronics, requires comparable amounts of manufacturing labor as ICEVs or can be even more labor-intensive (Cotterman et al. 2024; Küpper et al. 2020). Cotterman et al. (2024) find that BEV power trains require more labor hours than ICEV power trains, primarily due to the complexity of battery cell manufacturing and the assembly of battery packs. The production of batteries is a labor-intensive process involving specialized manufacturing and assembly steps. Despite these emerging findings, the fear that BEVs will eliminate thousands of automotive manufacturing jobs persists (Pontecorvo 2023). Regardless of a net-positive job creation outcome, the impact distribution will be uneven across the types of auto manufacturing jobs. Thus, it is imperative that more attention is given to which automotive manufacturing jobs are at risk and how those workers should be supported during the transition.

Second, the shift toward BEVs has prompted questions about the quality of jobs in the automotive industry. Automotive manufacturing historically provided well-paying jobs and was once seen as a ticket to the middle class. The sector also has a high share of workers with only a high school degree compared to other sectors (Saha et al. 2023). Although US automotive manufacturing workers have seen a decline in wages and working conditions in recent decades, average hourly earnings are still higher than the national average wage (BLS 2025a, 2025c). The shift toward BEVs has raised concerns about whether the thousands of workers needed in battery manufacturing facilities will earn wages comparable to workers at automotive assembly facilities (White House 2021). For instance, prior to a wage-increase agreement reached between United Auto Workers (UAW) and Ultium Cells, a joint venture between GM and LG Energy Solution, the starting wage at Ultium Cells was US$15.50 an hour—half of the top wage for assembly-line workers at GM's assembly facilities (Bayless 2023; LaReau 2023). The main concern with the wage disparity is that if lower wages in mostly nonunionized battery manufacturing facilities become the norm, then the BEV transition will not be a fair or adequate replacement for lost jobs in ICEV manufacturing. The wage-increase agreement resulted in a 25 percent wage increase across all hourly working positions at Ultium Cells.

Finally, the geographic concentration of automotive manufacturing and the outsized importance the industry plays in local economies raise additional concerns regarding the impact of the BEV transition on jobs that are closely tied to ICEV manufacturing. Nationally, the automotive manufacturing industry is important to the US economy, accounting for 5 percent of gross domestic product (GDP) (Alliance for Automotive Innovation 2025). The United States is currently the second-largest automotive manufacturer in the world—after China—and produced close to 11 million motor vehicles in the 2023 calendar year, making up 11 percent of all motor vehicle production globally (Alliance for Automotive Innovation 2025). In 2024, over 1 million workers were directly involved with the manufacturing of automobiles or automotive supplies across the United States. At the same time, the industry has played a particularly important role in the economies of several midwestern and southern states (Hill et al. 2010; Thompson and Merchant 2010). Nearly half of all US motor vehicle parts manufacturing jobs were concentrated in four states—Michigan, Ohio, Indiana, and Kentucky—and motor vehicle manufacturing employment (i.e., vehicle assembly and finished vehicles) in these four states accounted for 30 percent of total US motor vehicle manufacturing employment (BLS 2025a). Although other segments of the automotive vehicle chain, such as repair and maintenance, will also be impacted by the BEV transition, they are more geographically dispersed across the country and are less politically organized than manufacturing workers, who have long held significant political influence and have advocated for stronger labor standards and working conditions (Reolfi et al. 2023).

> The scale of the automotive manufacturing industry—and the range of the workers that compose it—highlights the importance of this research and understanding how the industry will change as the demand for BEVs grows.

Therefore, it is important to examine how the BEV transition will impact automotive manufacturing jobs—both in terms of changes in demand for various jobs as well as changes in the nature and quality of jobs. This analysis focuses on answering the following questions:

- What types of automotive manufacturing occupations are at risk of disruption, and what transition pathways exist for workers in those occupations?
- What new occupations and skills associated with BEV manufacturing will be in demand?
- How will the BEV transition influence key workforce considerations, such as job quality, geography of jobs, and workforce inclusivity and diversity?
- How can key stakeholders—including industry employers, state officials, labor organizations, and training and education providers—build an opportunity-rich BEV industry that leaves no worker behind?

The research team applied a combination of research methods to answer these questions. First, the team conducted secondary data analyses using various public data sets to explain the US automotive manufacturing supply chain and different aspects of the industry, such as employment, wages, and geographic distribution. Researchers also reviewed different data sets to better understand where EV manufacturing investments and facilities have been announced in the country. They then surveyed auto manufacturing firms to develop a deeper understanding of current industry perceptions, needs, and priorities for the BEV transition. The research team also hosted three advisory council (AC) meetings and interviewed different industry stakeholders to inform the report's findings and recommendations. Further details on different parts of the research are discussed below in the "Research methods" section.

Shifting the automotive manufacturing workforce to BEVs

The key takeaway from this analysis is that the BEV transition entails a significant shift in the automotive manufacturing workforce, requiring new skills and training to handle the specialized technologies and manufacturing processes involved. A small subset of automotive manufacturing workers, particularly those focused on ICEV-specific power train components, is likely to face the greatest relative disruption. Those workers may need substantial retraining to transition to other jobs that are growing in BEV manufacturing and other adjacent industries that require similar skill sets. Additionally, a new pipeline of workers with the necessary skills to fill new and emerging roles in growing segments of automotive manufacturing, such as battery and power electronics manufacturing, will be needed.

Education and training, upskilling, and reskilling initiatives are imperative to equip workers with the competencies to thrive in a new, electrified manufacturing environment. Although automotive manufacturers are primarily responsible for training their workforce, government agencies and educational and training institutions are pivotal partners in building a BEV-ready workforce. By aligning curricula and training programs with industry needs and supporting vocational training and apprenticeship programs, government and educational and training partners play an important role in developing the workforce pipeline that can power the electric manufacturing revolution.

The analysis presented in this report can help ensure that the BEV transition enables workers, employers, and communities to reap the benefits and opportunities presented by the transition. It shows that sourcing new entrants into the BEV manufacturing workforce, as well as upskilling and reskilling existing automotive manufacturing workers, will help create a more diverse workforce and provide higher-quality jobs in the industry.

Research methods

This section describes the different research methods that were used to better understand the workforce implications of the US automotive manufacturing industry shift toward BEV production. Methods include a literature review, secondary data analysis, a survey of automotive manufacturing firms, and semistructured interviews with key stakeholders. The research team also gathered feedback from an advisory council on different research questions and outputs through three meetings at different stages of the project.

This report uses a mixed-method approach to understand the workforce implications of the shift toward BEVs. This method allows for a comprehensive analysis by combining both quantitative and qualitative data and drawing upon information from multiple sources. Table 1 provides a summary of the research methods, and further details are provided below.

Literature review

The literature review included various sources to develop a better understanding of different aspects of the US automotive industry, key characteristics of its workforce, and the transition from manufacturing ICEVs to BEVs. It focused on the following categories of studies:

- **Studies evaluating manufacturing differences between ICEVs and BEVs.** ICEVs and BEVs have similarities as well as key differences. Both ICEVs and BEVs require different "fuel-agnostic" components (e.g., metal frames, seats, air bags, wheels, axles, and tires) (Saha et al. 2024a; Taylor et al. 2025). ICEVs, however, are powered by gasoline and rely on internal combustion engines and components such as fueling and exhaust systems as opposed to BEVs, which use electric motors and battery packs (Küpper et al. 2020). Key differences in power train components—the system of components that transfers energy from the engine to the wheels to make a car move—such as the propulsion and energy storage systems, are expected to be the greatest source of manufacturing differences between ICEVs and BEVs (Cotterman et al. 2022).

Based on an assessment of manufacturing differences between ICEVs and BEVs, a growing number of studies have begun to look at overlaps and differences in skills required to manufacture vehicle components and assemble vehicles. While initial comparative studies indicate that there are significant overlaps in the skill requirements for workers building BEV and ICEV power train components (Combemale et al. 2023; Cotterman et al. 2022), different needs in BEV-specific knowledge areas are emerging. In particular, new skill areas related to high-voltage systems, power electronics component manufacturing, and battery manufacturing are becoming salient. These require an understanding of battery chemistry and safety, battery materials engineering, and battery management systems, among other things (Krusemark et al. 2024; Saha et al. 2024a; SME n.d.a). Additionally, BEV manufacturing and broader industry changes, such as an increasing shift to automation, are likely to emphasize the need for advanced manufacturing skills related to diagnostics, testing/quality control, managing electrical components, managing automated tools, and data analysis (Krusemark et al. 2024; Saha et al. 2024a).

The literature review indicates that battery technology—focusing on the design and characteristics of the battery itself—and related skills have received more attention. Analysis and identification of other skill sets arising from differences between BEVs and ICEVs, such as power train design and manufacturing processes, have been less studied.

TABLE 1 | Summary of research methods

RESEARCH METHOD	DESCRIPTION
Literature review and secondary data analysis	Focused on understanding key differences between ICEV and BEV components and manufacturing process, the structure of the US automotive manufacturing supply chain and its workforce, ICEV- and BEV-related occupations and skills, how manufacturing transitions already under way have affected workers, and how different parts of the industry could face disruptions based on how ICEVs and BEVs differ.
Survey of automotive manufacturing firms	Focused on getting deeper insights into industry and manufacturer perspectives, needs, and priorities for the BEV transition, with questions on workforce characteristics, general perceptions on the BEV transition, and key workforce considerations, including expected hiring and reskilling and training needs to transition to BEV manufacturing, among others.
Stakeholder interviews	Interviews from May–August 2024 focused on getting further insights from different relevant stakeholders on the US automotive manufacturing landscape, occupations and skills associated with ICEVs and BEVs, and the potential challenges and opportunities of the BEV transition.

Notes: BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.
Source: Authors.

- **Studies focusing on BEV workforce assessment and training needs.** This category of the literature review primarily included reports published by different state or federal agencies as well as other research organizations or industry experts. These sources explain how different parts of the industry are developing in a state or region, which manufacturers or suppliers are active or expected to commence operations, which types of occupations are expected to see a rise in demand and associated information (e.g., wages and required educational backgrounds for different occupations and demographic patterns), the landscape of training opportunities, and important considerations to help develop a pipeline of skilled workers. Key reports reviewed covered Georgia, Michigan, North Carolina, and South Carolina (DEW 2022; Gagnon Rodriguez and Trousdale 2024; Gandhi 2023; GDEcD 2023; North Carolina Department of Commerce 2019). Examples of other sources include the US Department of Energy (DOE) (2024) and Krusemark et al. (2024).

  A common theme across these sources is that the broad BEV manufacturing industry, covering different segments—battery manufacturing, vehicle design and development, vehicle components and parts manufacturing, and vehicle assembly—will require workers from diverse educational backgrounds, ranging from a high school degree to more advanced specialized degrees or certifications (Saha et al. 2024b; Vasilauskas et al. 2024). Another noticeable theme is that BEV workforce training programs in various formats, including apprenticeships, certificate programs, and postsecondary degree programs, are emerging across different states. A few efforts have attempted to identify and document different characteristics of such training programs, focusing on postsecondary institutions such as community colleges and four-year institutions in states receiving significant amounts of EV industry investments (Gowdy 2023; Shrestha et al. 2025). However, an in-depth evaluation of these programs is needed to clarify what types of workers are accessing and benefiting from training opportunities, identify the barriers to access, and outline lessons from the experiences of trainees and training providers.

- **Studies evaluating the net impact of the BEV transition on automotive manufacturing jobs.** The impact of the BEV transition on auto manufacturing jobs is a salient topic in the United States due to the size of the industry and its importance for local economies in various parts of the country. BEV power trains are mechanically simpler and have fewer moving parts than ICEVs, raising concerns of a reduction in labor intensity—with some analyses estimating a 30 percent reduction in auto manufacturing jobs[3]—needed for BEV assembly and BEV parts production compared to ICEVs (Hackett 2017; UAW 2020).

  However, more recent studies have started to provide a deeper picture, explaining that manufacturing BEV power train components is equally or more labor-intensive when different aspects of battery production are considered (Cotterman et al. 2024; Küpper et al. 2020). Vehicle assembly for BEVs could also require greater labor hours compared to ICEVs due to additional steps required for BEVs, such as the installation of charging units and power electronics (Küpper et al. 2020). Another study, which focused on three facilities that have fully transitioned from producing ICEVs to BEVs, found that the number of assembly workers increased for all three facilities (Weng et al. 2024).[4] There could be various reasons for this, including a trend toward vertical integration, where automakers are concentrating more production processes in-house; higher vehicle complexity, with automakers initially focusing on premium models with advanced features that require more labor for assembly; and investment in new technologies that require more workers to manage the learning curve and refine production processes.

  Although this report does not focus on analyzing the net impact of the BEV transition on automotive manufacturing jobs, familiarity with this literature is nonetheless necessary to begin to understand the types of automotive manufacturing occupations that are at risk of disruption and new occupations associated with BEV-related manufacturing that will be in demand.

- **Reports and news articles explaining key trends in the EV industry.** This includes US and global trends in EV sales, the geography of EV manufacturing investments and facilities, and automaker announcements. The Bipartisan Infrastructure Law and the IRA spurred private sector investments in EV manufacturing. Different organizations, such as Atlas Public Policy and the BlueGreen Alliance (Atlas Public Policy and BlueGreen Foundation 2025; Taylor et al. 2025) as well as the Environmental Defense Fund (EDF 2024), are tracking where investments into the EV and battery supply chain are occurring across the country. About $4.5 billion in EV manufacturing announcements have been canceled or scaled down as of September 2025 (Atlas Public Policy 2025). Furthermore, automaker announcements during the past year indicate that several companies are scaling back ambitious EV targets due to slower-than-expected demand growth. Fourteen automakers are now estimated to globally produce 23.7 million BEVs and PHEVs in 2030, compared to an earlier estimate of 27 million, due to automakers' adjusted electrification plans (Gallu and Eckl-Dorna 2025; Levin 2024). Although 2024 was a record year for EV sales, the market faces significant uncertainty in 2025. The impact of the Trump administration's unwinding of federal EV initiatives will become clearer in 2026 when vehicle sales numbers for 2025 are published.

The extensive literature review enabled the research team to develop a "parts list" (Table 2) that identifies and explains key differences in vehicle components between ICEVs and BEVs. The team relied on different sources, including ICEV and BEV parts catalogs, news articles, and sources that provide a teardown analysis of automobiles. The research team used this exploded parts list as an initial framework to identify and understand different industry segments along the vehicle manufacturing supply chain (including vehicle assembly and manufacturing of different vehicle components, including batteries) and which parts of the supply chain could face disruptions from the BEV transition. Further details and the sources used for this part of the research are provided in Appendix A.

TABLE 2 | Key differences between ICEV and BEV components

MAIN COMPONENT	RELEVANT NAICS[a] CODE:	DESCRIPTION	ICEV-SPECIFIC ATTRIBUTES	BEV-SPECIFIC ATTRIBUTES
Air-conditioning system	336390: Other Motor Vehicle Parts Manufacturing	Regulates cabin temperature	Powered by crankshaft	Independent electric motor that draws power from the vehicle battery
Transmission	336350: Transmission and Power Train Parts	Transmits power generated by the engine to the wheels via a mechanical system of gears	Multi-speed transmission with multiple gear ratios	Single-speed transmission (one gear only) with reduction gear mechanism (slows the BEV engine RPM output to match actual wheel rotation)
Suspension	336330: Steering and Suspension Components	Absorbs impact and terrain differences	Simpler suspension systems adapted for lighter vehicle weight	Suspension system modified to accommodate extra BEV weight and sometimes use fully independent suspension designs due to increased space in the car body
Cooling system	336390: Other Motor Vehicle Parts Manufacturing	Regulates engine temperature output	Single mechanical water pump driven by the serpentine belt (cooling system in ICEVs primarily focuses on regulating engine temperature)	Multiple electric water pumps that draw power from the vehicle battery (cooling system in BEVs is part of a broader thermal management system that controls the temperature of components such as battery, electric motor, and power electronics)
Engine	336310: Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	Powers vehicle	Internal combustion engine that burns fuel to push the pistons and rotate the crankshaft	Electric traction motor that converts electrical energy stored in a battery pack into kinetic energy to run the wheels; electric currents are generated in the stator and propel the magnets in the rotor
Exhaust system	336390: Other Motor Vehicle Parts Manufacturing	Vents heat and emissions out of vehicle	Entire exhaust system is ICEV specific	Not present in BEVs
Differential	336350: Transmission and Power Train Parts	Allows wheels to rotate at different speeds while turning	Differential is always needed in ICEVs because of the single-motor configuration	Differential needs to account for regenerative braking torque loads and the instant torque the electric engine produces
Braking system	336340: Motor Vehicle Brake System	Slows car down	Disc braking system that creates friction between the brake caliper and steel rotor disc, slowing the car	Regenerative braking system where the BEV engine process reverses: the rotors capture kinetic energy from the wheels and generate electric currents that the stator absorbs and stores in the battery
Vehicle electronics	336320: Motor Vehicle Electrical and Electronic Equipment Manufacturing	Components that control electrical systems or subsystems in the vehicle	ICEVs typically have an electronic control module that monitors different sensors to optimize engine operation	BEVs require additional electronic components and systems, including converters and inverters, high-voltage wiring, and power electronics controller

Notes: The table does not show differences in fuel/energy storage components (i.e., fuel tank and battery pack) and vehicle software-related differences because the North American Industry Classification System (NAICS) does not have codes that specifically depict such vehicle components. BEV = battery electric vehicle; ICEV = internal combustion engine vehicle; RPM = revolutions per minute; [a] The NAICS is a standardized framework used by federal agencies to classify industries and businesses in the United States. This classification system currently does not distinguish between manufacturing of gas-powered and electric cars.

Source: Authors; US Census Bureau 2025.

Secondary data analysis

The literature review was complemented with an analysis of different publicly available data sets to evaluate industry and occupation-level employment, wages, and demographics of the US automotive manufacturing industry. An important component of the secondary data analysis was to explain the structure of US automotive supply chain and employment patterns in various industries and occupations involved in vehicle manufacturing (see "Structure of the automotive manufacturing industry and its supply chain").

Building on Table 2, the analysis used available data to provide a starting point to understand different parts of the US vehicle manufacturing supply chain, key workforce characteristics (e.g., the size and geographic distribution of the workforce in various industries), and how different parts of the supply chain could be impacted during the BEV transition. Original equipment manufacturers (OEMs) and Tier 1 industries within automotive manufacturing are categorized by their risk of disruption:

- **Significant disruption** (due to manufacturing activity being specific to ICEVs; e.g., gasoline engine manufacturing). *Significant disruption* would entail greater effort to reskill or adapt and may even pose a threat of the occupation disappearing.
- **Moderate disruption** (due to some differences in manufacturing processes for ICEVs and BEVs; e.g., braking systems manufacturing). *Moderate disruption* would involve learning some new tasks. In this scenario, workers are more likely to easily transition with upskilling efforts.
- **Minimal disruption** (due to minor or no differences in manufacturing processes for ICEVs and BEVs; e.g., car interiors and steering systems). *Minimal disruption* would entail comparatively fewer new tasks and learnings, and work would remain largely unchanged.

Table 3 categorizes different US OEMs and Tier 1 industries[5] in the automotive supply chain according to the differences identified in Table 2, using the North American Industry Classification System (NAICS) (see Box 1 for further details on the NAICS). The classification of OEMs and Tier 1 industries was developed by linking the NAICS codes and associated components to the exploded parts list in Table 2.

TABLE 3 | Classification of OEMs and Tier 1 industries within automotive manufacturing by risk of disruption due to the BEV transition

SIGNIFICANT DISRUPTION (due to manufacturing activity being specific to ICEVs)	**MODERATE DISRUPTION** (due to some differences in manufacturing processes for ICEVs and BEVs)	**MINIMAL DISRUPTION** (due to minor or no differences in manufacturing processes for ICEVs and BEVs)
▪ 336310: Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	▪ 336320: Motor Vehicle Electrical and Electronic Equipment Manufacturing ▪ 336340: Motor Vehicle Brake System Manufacturing ▪ 336110: Automobile and Light Duty Motor Vehicle Manufacturing ▪ 336390: Other Motor Vehicle Parts Manufacturing ▪ 336350: Motor Vehicle Transmission and Power Train Parts Manufacturing	▪ 336330: Motor Vehicle Steering and Suspension Components ▪ 336360: Motor Vehicle Seating and Interior Trim Manufacturing ▪ 336370: Motor Vehicle Metal Stamping ▪ 336211: Motor Vehicle Body Manufacturing

Notes: The North American Industry Classification System (NAICS) does not have a code specifically for exhaust system manufacturing. Exhaust systems are currently included under 336390: Other Motor Vehicle Parts Manufacturing, which covers a wide range of vehicle components (ranging from air bags to air conditioners, radiators, air filters, engine exhaust, among others). Because components such as exhaust systems are lumped together with other products, it is difficult to separate out the industry that exclusively focuses on ICEV-specific parts such as exhaust systems. The research team opted to classify NAICS 336390 under the "moderate disruption" category due to the wide range of components this NAICS code covers (including fuel-agnostic components), with the understanding that individual components exhaust systems may compose a very small fraction of this NAICS code industry. OEM = original equipment manufacturer; BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.

Source: Authors, using BLS 2023d and US Census Bureau 2025.

BOX 1 | US automotive manufacturing industries under the North American Industry Classification System

North American Industry Classification System (NAICS) codes are used by federal agencies such as the US Bureau of Labor Statistics to classify industries and businesses based on how they produce goods or services for the collection of economic data (employment, wages, etc.). NAICS codes follow a hierarchical system, where the first two digits represent broad sectors (i.e., manufacturing, construction, services, etc.) and the following four digits define a more specific activity in subsectors and industries (US Census Bureau 2025). Manufacturing-focused sectors fall under NAICS codes 31–33, with NAICS 336 representing the transportation equipment manufacturing subsector. NAICS 336 is further broken down to more specific industries, such as NAICS 3361 (Motor Vehicle Manufacturing), NAICS 3362 (Motor Vehicle Body and Trailer Manufacturing), and NAICS 3363 (Motor Vehicle Parts Manufacturing). Within these four-digit NAICS code categories associated with motor vehicle manufacturing, the research team selected available six-digit NAICS codes that depict vehicle components and original equipment manufacturers (OEMs) and Tier 1 manufacturers. For instance, under NAICS 3361, which broadly captures all motor vehicle manufacturing, NAICS 336110 was selected because it represents businesses such as OEMs, which are primarily engaged in manufacturing complete automobiles or light-duty vehicles and vehicle assembly. Likewise, under the NAICS 3363 category, NAICS codes were selected that represent manufacturers of various specific motor vehicle components and subcomponents.

Source: NAICS Association n.d.

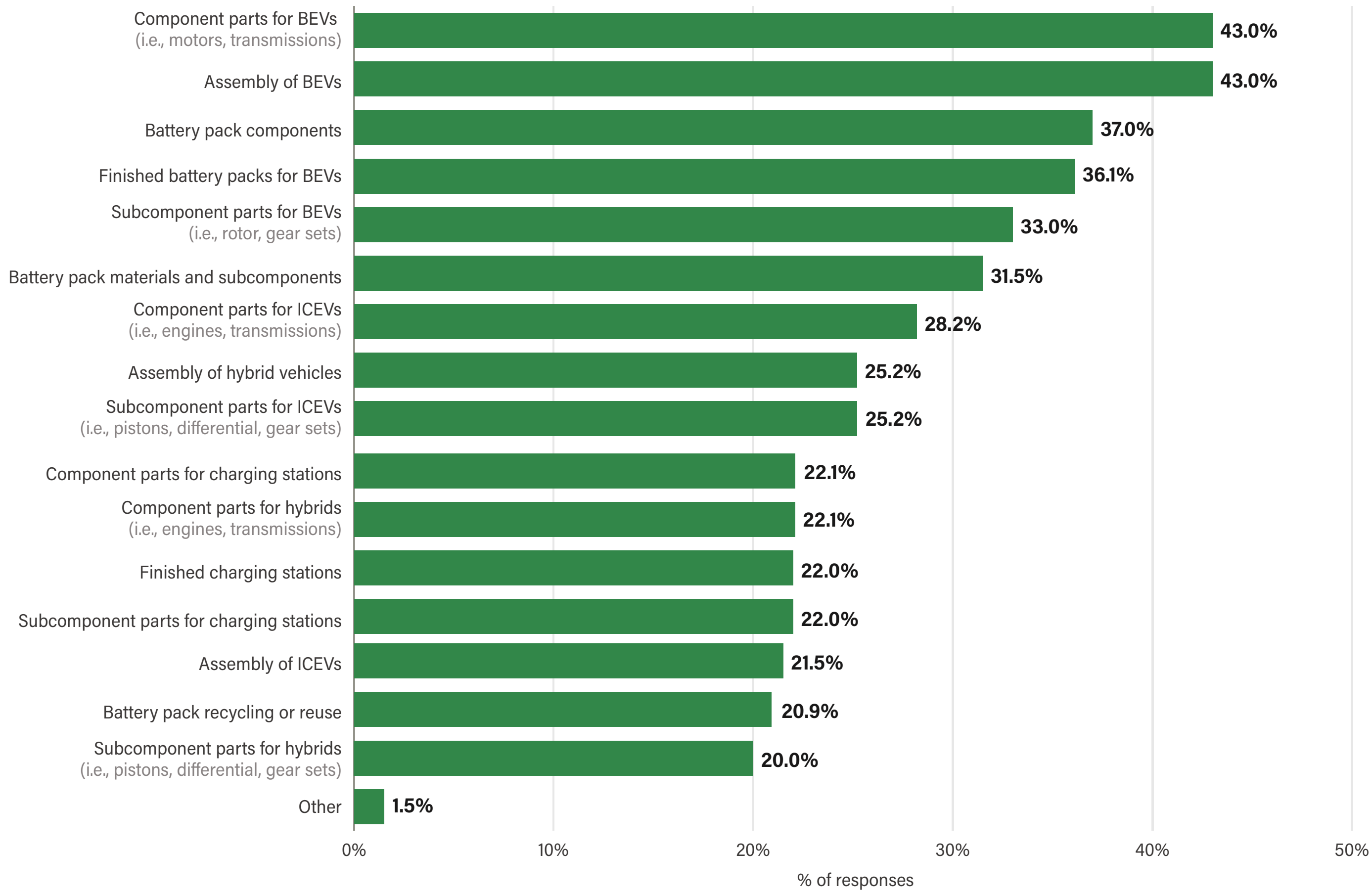
Key sources in the report's secondary data analysis included data sets such as the Quarterly Census of Employment and Wages from the US Bureau of Labor Statistics (BLS) (BLS 2023d), Employment Projections (BLS 2023a), and Occupational Employment and Wage Statistics (BLS 2023c). Occupation-level skills-related information is based on the US Department of Labor's O*NET OnLine (DOL ETA n.d.a), an online database that contains standardized and occupation-specific descriptors on almost 1,000 occupations covering the entire US economy. EV manufacturing-related investment and facility announcement data were mainly obtained through the DOE's Building America's Clean Energy Future map (DOE 2025) data set and Environmental Entrepreneurs' Clean Economy Works data set (E2 2025), which track announced clean economy projects at the facility level. The analysis also referred to the US Energy and Employment Report (USEER), which provides a comprehensive summary of national-, state-, and county-level energy jobs, reported by industry, technology, and region, with data on unionization rates, demographics, and employer perspectives on growth and hiring (DOE and BW Research 2024).

Survey of automotive manufacturing firms

The research team conducted a national survey of automotive manufacturing firms to develop a greater understanding of industry perceptions, needs, and priorities for the BEV transition. This survey included three main sections ("Section 1: Employment," "Section 2: Worker transitions," and "Section 3: The transition to BEVs"). Each section asked questions on different aspects, such as the size of the firm's workforce, perceptions of the BEV transition, and workforce considerations (expected hiring and reskilling needs, etc.).

To qualify for the survey, potential respondents had to be involved with the manufacturing or design of finished or component goods for light-duty BEVs, BEV battery packs or materials, or BEV charging stations.[6] Following this initial screener question, survey respondents were then asked to choose which product lines pertained to their business; respondents were allowed to choose multiple products across automotive and charger manufacturing, as shown in Figure 1. Respondents were identified and recruited using a combination of known automotive manufacturing firms from previous survey research, samples from industry associations, and a panel of respondents provided by a third party. The survey was programmed internally by BW Research, and each respondent was assigned a unique identifier to prevent duplication.

FIGURE 1 | Breakdown of survey respondents by product type



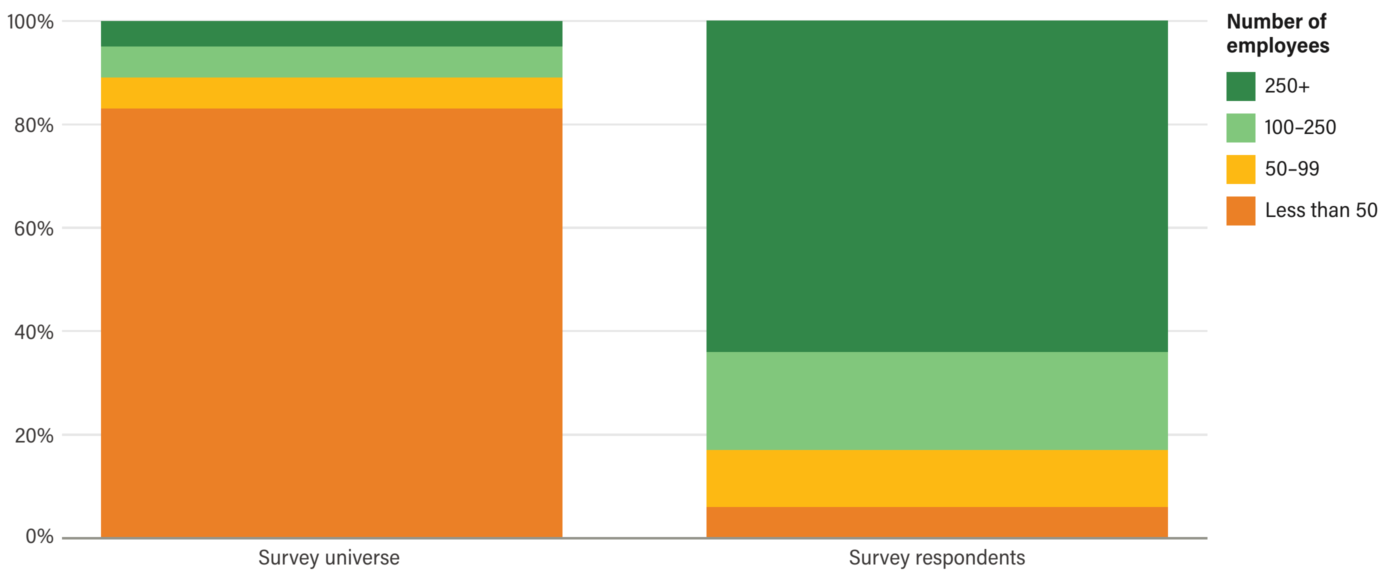
Note: Percentages do not add up to 100 because respondents were allowed to select multiple choices. N (number of responses) = 330. BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

The survey was fielded between May and August 2024, resulting in 330 total complete responses, with an average survey response duration of 13 minutes. Of the survey respondents, 64 percent reported that they employ 250 or more employees (Figure 2), 30 percent employ 50–249 employees, and 6 percent employ fewer than 50 employees. Most survey respondents reported that they produce component parts for BEVs (i.e., motors, transmissions), assemble finished vehicles, or produce battery pack components or finished battery packs (Figure 1). Further breakdowns of survey responses by firm size and by product type are available in Appendix B, along with a full survey methodology.

Although the survey received over 300 responses from a wide group of firms, selection bias may still be present in survey results, which can lead to differences between survey findings and the actual on-the-ground reality. Hence, the report frames all quantitative survey findings around the survey sample rather than the universe of all US automotive manufacturing firms. A comparison of all firms that received the survey and survey respondents is shown in Table B-2 (Appendix B). Another feature in the survey is that larger firms (firms with more than 250 employees) made up a greater proportion of the survey responses compared to the proportion of these firms in the survey universe (Figure 2). As a result, further evaluation is needed to explore the perceptions, needs, and challenges of smaller and medium-sized firms to present a fuller picture of potential workforce impacts of the BEV transition.

FIGURE 2 | Breakdown of survey universe and survey respondents by firm size



Note: N (number of responses) = 330.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

Stakeholder interviews

The research team also conducted 19 semistructured stakeholder interviews to better understand the perspectives of automotive manufacturing employers, unions, industry and community-based organizations, and state and local governments. These conversations attempted to gain further insights into the passenger vehicle manufacturing landscape, different occupations and skills associated with ICEVs and BEVs, and the potential challenges and opportunities that arise with the transition to BEVs.

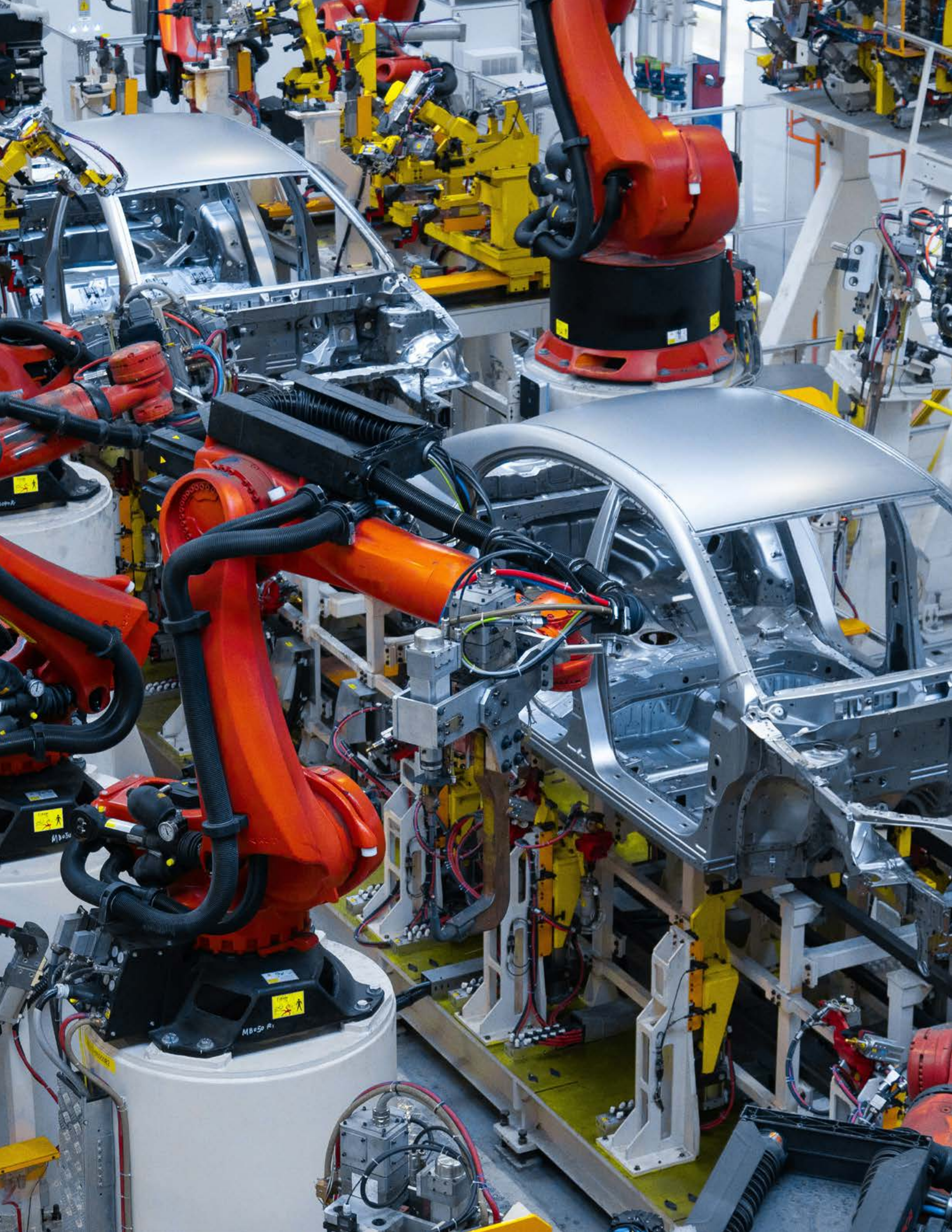
The interview questionnaire template is provided in Appendix C.

Advisory council

To inform the report objectives, research process, and key findings, an advisory council (AC) comprising a diverse group of industry experts and stakeholders was created. This group included nine members from a wide range of organizations, including a DOE national lab, automotive industry experts, and national consortiums or associations focusing on workforce implications of BEVs, among others. The research team hosted three AC meetings designed to give the research team deeper insight into challenges that industry stakeholders face, research findings to date, and potential solutions and policy recommendations.

The first AC meeting focused on discussing the main trends and findings from the secondary data analysis and seeking AC input into the design of the survey questionnaire. This was followed by a second meeting that included a discussion on the main themes from the survey results and how they can inform policy needs and recommendations. The final meeting focused on developing policy recommendations, including an importance/difficulty matrix group exercise to categorize and rank different policy recommendations.

It is important to note here that the participation of different stakeholders in this research does not signal their endorsement of all recommendations presented in this report. The findings, recommendations, and conclusions drawn in this report solely reflect the views of the research team and should not be attributed to any other individuals or organizations.



Structure of the automotive manufacturing industry and its supply chain

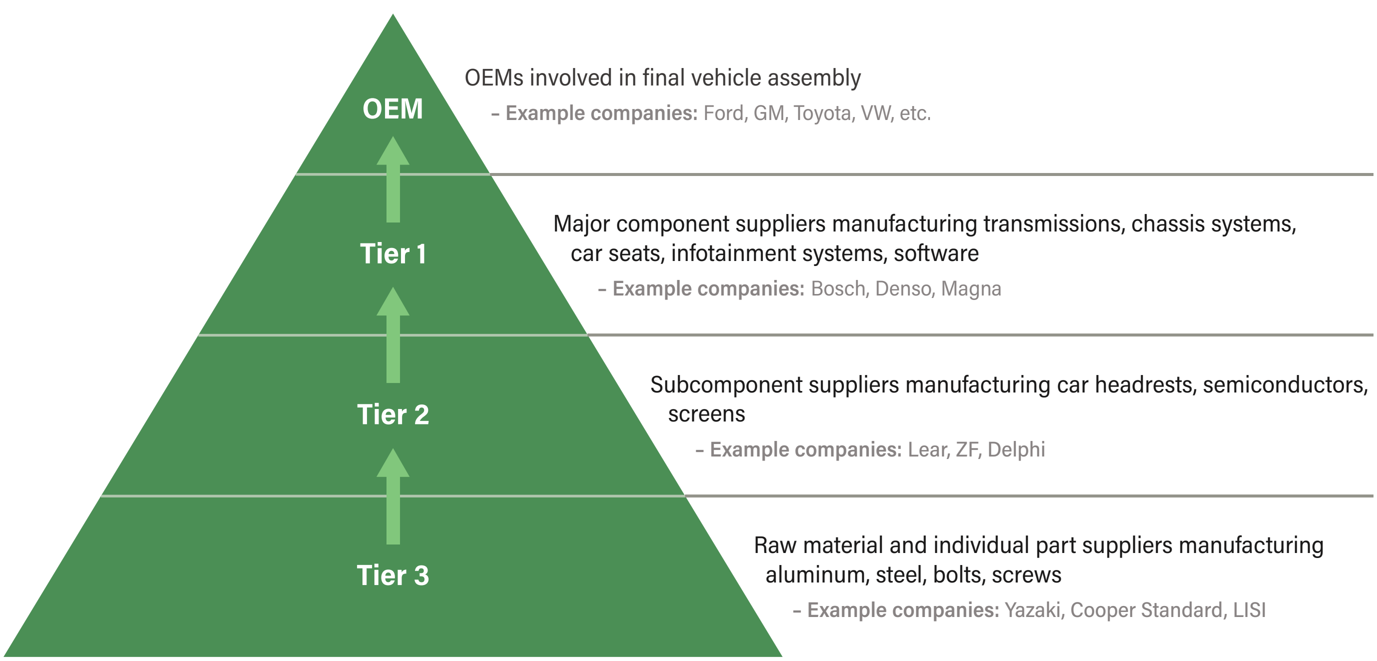
This section explains the structure of the automotive manufacturing industry and its supply chain, including employment patterns across the supply chain and in different regions of the country. It also discusses the major trends in automotive manufacturing, many of which are directly or indirectly catalyzed or accelerated by the transition to BEVs. The discussions in this section are informed by the literature review and the secondary data analysis.

Description of the industry and its employment pattern

The motor vehicle industry is a large industry with complex supply chains. Figure 3 illustrates the structure of the legacy automotive supply chain. The OEMs, such as Ford, GM, Hyundai, Stellantis, Toyota, and others, make up the smallest number of firms but represent the final assembly of vehicles. Typically, these OEMs have focused on design and assembly of automobiles, leaving the manufacture of axles, bearings, transmission, and suspension parts to thousands of other manufacturers. The next layer down in the supply chain, henceforth referred to as "Tier 1" (BlueGreen Alliance n.d.), consists of the major component suppliers to OEMs: they have the most direct relationship with the OEMs and provide the finished components to OEMs for final vehicle assembly, testing, and quality control. Next, Tier 2 suppliers provide subcomponents or parts to Tier 1 suppliers, and Tier 3 suppliers provide raw materials and individual parts to Tier 2 suppliers.

Most employment in automotive manufacturing is upstream of the OEMs. Independent suppliers still manufacture most of the parts and components that go into the final vehicle. However, the transition to BEVs is altering this traditional automotive supply chain. As of the third quarter of 2023, an estimated 258,523 workers were employed in OEMs; 624,939 in Tier 1–related industries (Table 4);[7] and an additional 196,673 in Tier 2– and Tier 3–related industries (see Appendix D) farther down the supply chain (BLS 2023d). In total, more than 1 million workers (1,080,135) were directly involved with the manufacturing of automobiles or automotive supplies across the United States (BLS 2023d). OEMs only account for 24 percent of employment. It is likely that as the industry pivots to more vertical integration and OEMs take over more component production (as discussed later in "Trends in automotive manufacturing and broader industry and policy changes"), their employment share may increase as they need to hire workers with a broad range of expertise across significant portions of the production process. However, this is not guaranteed because there are other changes happening in automotive manufacturing that intersect with the trend of vertical integration—with implications for jobs and workers.

FIGURE 3 | Legacy automotive manufacturing supply chain



Notes: OEM = original equipment manufacturer; GM = General Motors; VW = Volkswagen.
Source: Authors.

TABLE 4 | US employment in OEMs and Tier 1 suppliers in automotive industries

NAICS CODE	NAICS DESCRIPTION	Q3 2023 EMPLOYMENT (IN THOUSANDS)	EMPLOYMENT CHANGE, 2019–2023 (%)
336110	Automobile and Light Duty Motor Vehicle Manufacturing	258.5	26.3
336390	Other Motor Vehicle Parts Manufacturing	153.5	-2.2
336370	Motor Vehicle Metal Stamping	82.7	-7.4
336350	Motor Vehicle Transmission and Power Train Parts Manufacturing	79.5	-4.9
336360	Motor Vehicle Seating and Interior Trim Manufacturing	75.2	-5.7
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	61.8	-4.9
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	58.0	-8.2
336211	Motor Vehicle Body Manufacturing	59.6	1.9
336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	33.6	-0.5
336340	Motor Vehicle Brake System Manufacturing	21.1	-18.0
Total OEM and Tier 1 employment (Q3 2023)		**883.5**	**2.7**
Total number of vehicles produced in the United States (2023)[a]		**14,196,404**	
Total number of vehicles produced in the United States (2019–23, % change)[b]		**-11.3**	

Notes: Authors estimated US original equipment manufacturer (OEM) and Tier 1 employment by identifying available North American Industry Classification System (NAICS) codes that represent vehicle manufacturers and vehicle component/subcomponent manufacturers and by collecting corresponding employment data from the Quarterly Census of Employment and Wages from the US Bureau of Labor Statistics (BLS). NAICS 336110 represents OEMs that are primarily engaged in manufacturing complete automobiles or light-duty vehicles and vehicle assembly. The remaining NAICS codes represent Tier 1 suppliers. The employment numbers shown above include those associated with manufacturing gas-powered vehicles and battery electric vehicles (BEVs). This is because the NAICS codes do not distinguish between manufacturing of gas-powered and BEVs. As a result, the NAICS classification does not provide information about the labor force involved exclusively in BEV manufacturing. Q3 = third quarter; [a.] Shows number of gas-powered cars produced in the United States in model year 2023. (The US Environmental Protection Agency defines a model year as a manufacturer's production period for a particular vehicle. A typical model year for a vehicle begins in the fall of the preceding calendar year and runs until late in the next calendar year. As an example, "light-duty vehicles produced in model year 2023" refers to cars classified and designed as the "2023 model year" by a manufacturer, which may have been physically produced in late 2022 or 2023). [b.] Shows percentage change in 2019 and 2023 model year light-duty vehicle production.

Source: Authors, using BLS 2023d and EPA 2024b.

Automotive manufacturing jobs are heavily concentrated in the Midwest and the South. The Midwest is known as the "original" hub of the US auto industry, with states here being the home of technological innovation and growth in the industry since the early 1900s. Another regional hub has emerged in the southern region, with various foreign "transplant" automakers investing heavily in the South over the past three decades, particularly in Kentucky, Tennessee, Alabama, and South Carolina (Hughes-Cromwick 2021). States in the Midwest and the South now constitute two regional hubs for motor vehicle assembly and parts manufacturing in the country (Hughes-Cromwick 2021; Saha et al. 2024b). Of the 883,462 workers in OEMs and Tier 1 auto industries as of 2023, over 50 percent (474,511 workers) are located in five states: Michigan, Ohio, Indiana, Tennessee, and Kentucky (Table 5). Michigan, which has often been referred to as the heart of the American automotive industry, leads in OEM and Tier 1 employment, driven by its strong network of legacy automakers and suppliers (BLS 2023d).

Targeted EV legislation is boosting BEV production and manufacturing job growth. BEV-specific employment, including in BEV manufacturing, has seen substantial growth over the last four years, likely in part spurred by the EV tax credits included in the IRA and the Bipartisan Infrastructure Law's investment in a national charging network system.[8] In 2018, before this wave of legislation promoting the adoption of BEVs, the entire BEV value chain—BEV manufacturing, repair and maintenance, wholesale trade, and professional and business services industries—employed an estimated 76,400 workers in the United States (DOE and BW Research 2024).[9] Employment growth was modest between 2018 and 2020 (2–8 percent increase), but following targeted EV

TABLE 5 | Ten US states with most OEM and Tier 1 employment (in thousands), third quarter of 2023

STATE	OEM AND TIER 1 EMPLOYMENT[a]	OEM		TIER 1			
		Employment in OEM[b]	OEM (%)	Employment in motor vehicle parts manufacturing[c]	Motor vehicle parts manufacturing (%)	Employment in motor vehicle body manufacturing[d]	Motor vehicle body manufacturing (%)
Michigan	178.5	49.0	27.4	122.8	68.8	6.8	3.8
Ohio	87.4	17.1	19.5	66.4	75.9	4.0	4.6
Indiana	81.7	21.3	26.1	56.3	68.9	4.1	5.1
Tennessee	65.5	20.6	31.4	43.3	66.0	1.7	2.5
Kentucky	61.4	23.2	37.9	34.8	56.7	3.3	5.4
Alabama	52.4	21.0	40.0	29.6	56.5	1.8	3.5
California	46.2	30.2	65.2	12.3	26.5	3.8	8.3
Texas	43.1	15.9	36.9	24.6	57.1	2.6	6.0
Illinois	40.1	14.8	37.0	22.7	56.7	2.5	6.3
South Carolina	35.4	13.7	38.7	21.3	60.0	0.5	1.3
Other states	191.7	31.8	16.6	131.4	68.6	28.4	14.8
US total	883.5	258.5	29.3	565.3	64.0	59.6	6.7

Notes: The employment numbers shown above include those associated with manufacturing gas-powered vehicles and battery electric vehicles (BEVs). This is because the standard classification system for businesses and employment in the United States—North American Industry Classification System (NAICS)—does not distinguish between manufacturing of gas-powered and battery electric cars. As a result, the NAICS classification does not provide information about the labor force involved exclusively in BEV manufacturing. OEM = original equipment manufacturer; [a.] Sum of state employment in different NAICS codes; [b.] State employment in NAICS code 336110 (Automobile and Light Duty Motor Vehicle Manufacturing); [c.] State employment in motor vehicle parts manufacturing associated with NAICS codes that fall under the NAICS 3336 category; [d.] State employment in NAICS code 336211 (Motor Vehicle Body Manufacturing).

Source: Authors, using BLS 2023d.

legislation, annual BEV employment growth has ranged from 13 percent to 27 percent between 2021 and 2023. In 2023, BEV employment reached 149,700 workers, nearly doubling its 2018 employment. Of these 149,700 jobs, over a third (38 percent) are concentrated in BEV manufacturing (DOE and BW Research 2024).[10]

In the US metropolitan areas that experienced the highest job growth in automotive manufacturing over the 2019–23 period—namely, Phoenix (Arizona), Bloomington (Illinois), Dallas (Texas), Elkhart (Indiana), San Francisco (California), and Chattanooga (Tennessee)—major BEV manufacturing facilities account for a large share of their auto manufacturing jobs and likely the auto industry job gains. According to Denham (2024), a different major automotive manufacturer accounts for a large share of automotive manufacturing jobs in each of these metropolitan areas, including the Lucid Motors production facility in Phoenix, Rivian's production facility that replaced a Mitsubishi facility in Bloomington, and Tesla's factory in Fremont.

Trends in automotive manufacturing and broader industry and policy changes

The US automotive industry is experiencing significant changes, many of which are directly or indirectly catalyzed or accelerated by the transition to BEVs. Policy changes also have the potential to impact the industry. Technological and policy shifts have major implications for both the quantity and quality of jobs as well as demand for new skills in the BEV industry.

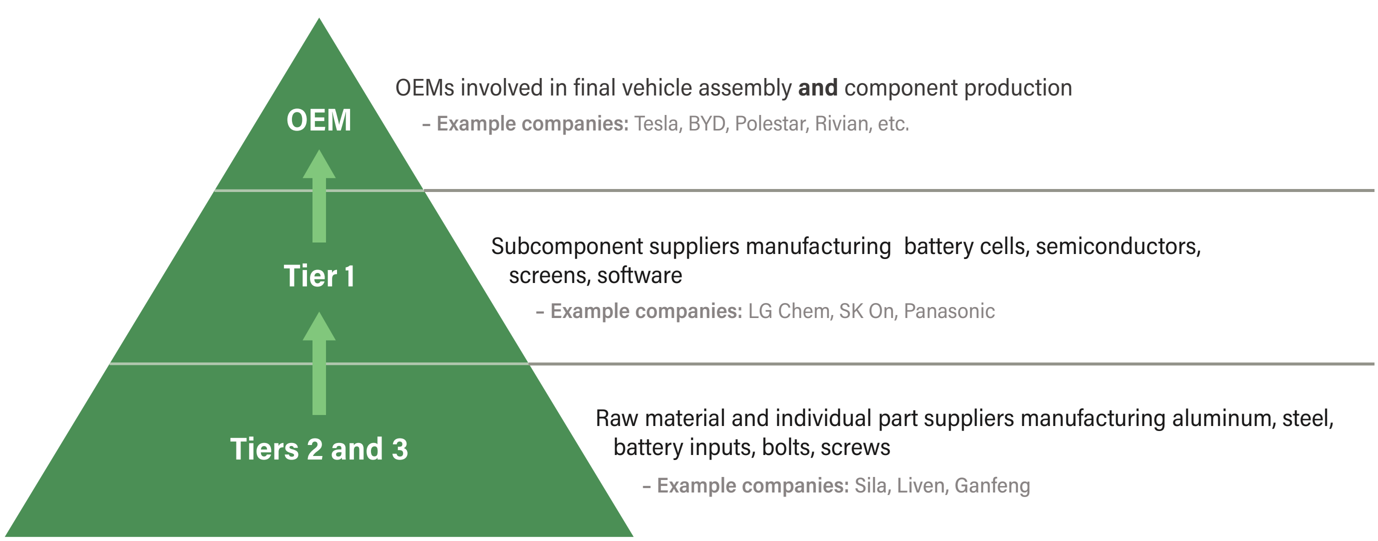
The BEV transition has increased the trend toward vertical integration in automotive manufacturing. Aside from the need to create new supply chains to support the novel technologies used in BEVs, automakers are demonstrating a renewed interest in vertical integration by moving vehicle component (e.g., battery, motors) production in-house to have more supply chain control, retain larger profit margins, and protect intellectual property (Isenstadt and Slowik 2023; Saha et al. 2024a). Tesla is a good example of a company leveraging vertical integration by taking control of battery production and even creating its own network of charging stations (Emmer 2024). GM has made significant investments to produce electric drive components—electric motor, a power electronic converter, and transmission—in-house as part of its strategy to develop and manufacture its BEV technology, known as Ultium Drive, rather than rely on external suppliers (Reuters 2020).

The shift toward BEV manufacturing is thus blurring the lines between OEMs and their traditional tiered suppliers (Figure 4). Vehicle components traditionally procured from Tier 1 suppliers, such as transmissions and chassis systems, are now often directly produced by BEV OEMs. Tier 2 firms now directly provide subcomponents to BEV OEMs. Tier 3 suppliers (providers of raw material inputs and individual parts) can be considered as Tier 2 firms due to their newfound proximity to BEV OEMs. The consequences of these changes, often referred to as *disintermediation*, include the diminished role for Tier 1 suppliers, especially for those focused on ICEV components such as exhaust systems and fuel injectors, and new opportunities for lower-tier firms.

The BEV industry is also investing in strategic partnerships and co-investment to navigate the immense cost and complexity of developing cutting-edge technology, especially related to battery production. A couple of examples of these shifts are Tesla's partnership with Panasonic to manufacture the battery cells used in its vehicles (Panasonic Group 2013) and Panasonic's partnership with Sila Nanotechnologies to provide silicon anode materials used in its battery production process (Panasonic 2023). Such partnerships and joint ventures that integrate different parts of the supply chain are also increasingly blurring the boundaries between OEMs and Tier 1–3 suppliers.

The changes in the supply chain due to vertical integration have clear workforce implications in two ways. The first impact has to do with how to measure and track employment across different categories of companies within the automotive manufacturing supply chain, especially when the framework for classifying the various companies in the automotive supply chain has not been modified to respond to ongoing shifts in the industry. The second, more profound, impact is with respect to skills building, workforce training, and potential worker displacement. On one hand, OEMs will now need to build capabilities and in-house expertise in

FIGURE 4 | BEV manufacturing supply chain



Notes: OEM = original equipment manufacturer.
Source: Authors.

battery technologies, inverters, and electric power trains. On the other hand, there is the potential of vertical integration consolidating the number of manufacturers and/or eliminating manufacturing jobs in the lower rungs of the supply chain. The impacts of vertical integration on the automotive industry and manufacturing jobs need to be further studied.

Automation and artificial intelligence (AI) are transforming the car production process. Automation has a deep history in automotive manufacturing, with the first industrial robot installed at the GM plant in New Jersey in 1961 (A3 2017). Even today, the automotive industry remains at the forefront of advancements in automation. It is second to electronics manufacturing in terms of the number of industrial robots installed (Müller 2022). AI also plays a pivotal role in nearly every aspect of automotive manufacturing, from initial assembly to final quality checks. AI algorithms, for instance, can analyze data from production lines to identify and prevent defects; AI-powered robots can assist with assembly, welding, and other manufacturing tasks; and generative AI can help generate new model designs.

AI's role is predicted to increase. By 2030, AI could automate up to 30 percent of current work hours, including a significant portion within the automotive industry (Hazan et al. 2024). BEV manufacturing is not immune from the growing trend of automation and AI and, in fact, could be accelerating the adoption of automation and AI.[11] Automation facilitates key tasks within the battery manufacturing process, including the use of robotic arms during the battery assembly process and automated battery management systems to monitor the battery's health, temperature, and charge levels. Similarly, AI can help develop new battery chemistries and materials (e.g., battery degradation and lifetime prediction or modeling; predicting chemical properties to help identify materials).

Workers will likely have to work with and alongside robots as well as possess AI skills like programming, machine learning, and data analysis, leading to a growing need for workers to understand the use and management of AI and other complex automated systems (Krusemark et al. 2024). Within the manufacturing process, this could include process optimization, quality control, and automation as well as predictive maintenance and diagnostics. AI also presents an opportunity for additional manufacturing and design activity. Systems such as advanced driver assistance, automated driving systems, and vehicle cabin digital systems will all require software developers who are capable of programming and testing these services as well as the manufacture and installation of the hardware that enables these systems. Many of these activities are captured in the "Adjacent growth industries" section of Appendix D (Table D-3).

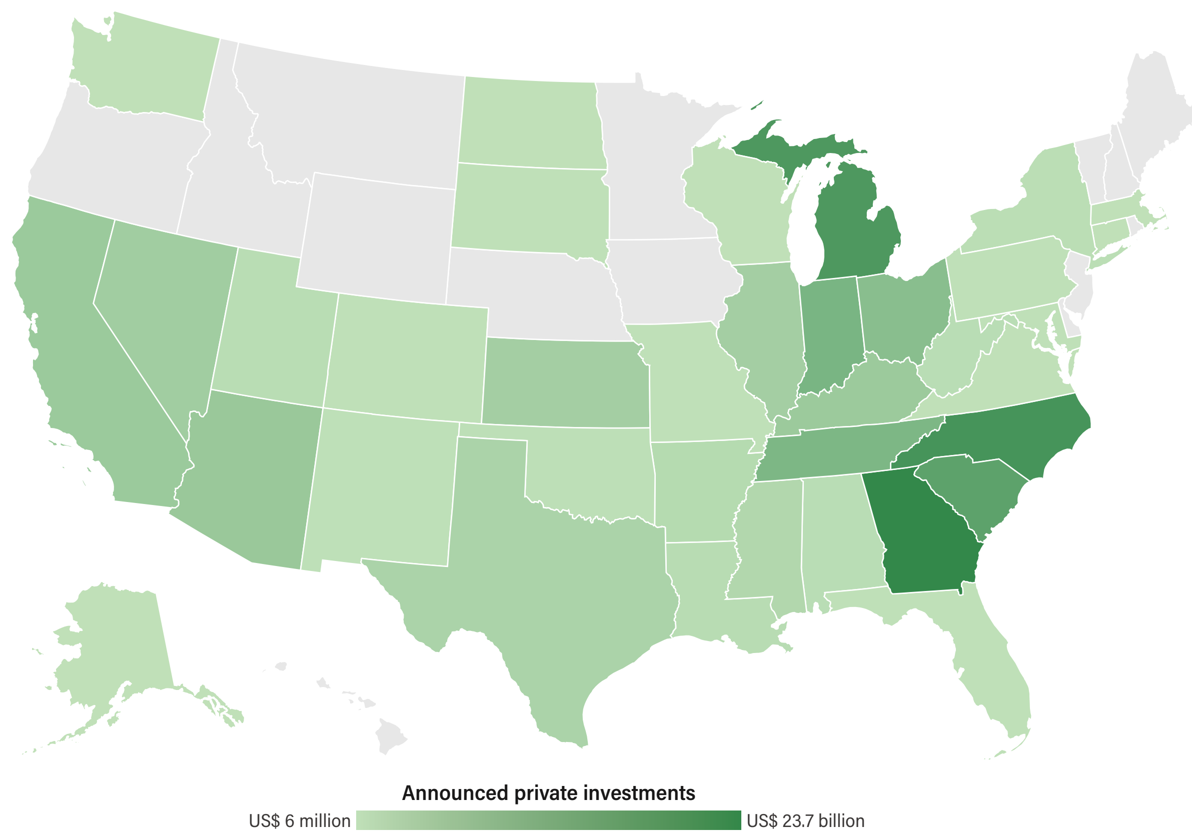
Differences between ICEV and BEV production lines will influence OEMs' decisions to transition plants or build new ones from scratch. This has implications for transitioning workers employed in ICEV manufacturing to BEV manufacturing, especially if new plants are constructed elsewhere. ICEV production lines typically utilize a rolling chassis or unibody structure in which the body is either installed onto the chassis (rolling chassis) or is part of the chassis. These two styles of production lines are different from how BEVs are increasingly manufactured, which is by a "skateboard" chassis where the motor, suspension, and brakes are attached to the battery support structure. This change of process matters because changing production from an ICEV factory to a skateboard chassis production line is much more expensive than simply switching production processes to a unibody chassis.

Furthermore, converting large-capacity ICEV-focused production centers to BEV plants can be more expensive than shutting them down. The primary reason is that current BEV production rates are still too low to justify the very high investment needed to completely retool a facility that has been designed to mass produce ICEVs (Cousineau 2022). Some legacy automakers, such as GM, are following a strategy of converting some facilities to produce both ICEVs and BEVs (Campbell 2024). In terms of workforce impacts, the blended strategy can enable automakers to manage a gradual transition, especially in the face of slower-than-expected BEV adoption. But it can also create unique challenges for training and job roles compared to a full-scale conversion to BEV-only manufacturing.

EV manufacturing has seen a significant rise in investments, but recent policy changes create uncertainty. As of September 2024, manufacturers had announced \$199–\$208.8 billion in investments for US EV and EV battery manufacturing facilities (EDF 2024; Taylor et al. 2025). Federal policies such as the Bipartisan Infrastructure Law and the IRA have played an important role in attracting EV industry investments in the country. Of these private investments, 63–72 percent have occurred in the last two years since passage of the IRA (EDF 2024; Taylor et al. 2025). Overall, announced investments indicate that the BEV manufacturing industry is poised to grow in multiple states throughout the country (Figure 5), with investments entering states that have traditionally been the backbone of US auto manufacturing as well as states that were not previously involved in the auto industry (EDF 2024; Saha et al. 2024b). As announced manufacturing facilities become fully operational, the BEV industry has the potential to become a more prominent source of employment, tax revenues, and wider induced economic benefits in different parts across the country. For instance, one analysis found more than 250,000 *announced* EV manufacturing jobs across 35 states as of January 2025 (Atlas Public Policy and BlueGreen Alliance Foundation 2025).[12]

Changes introduced by the One Big Beautiful Bill Act have raised uncertainty and may slow the transition, but it will be hard to fully reverse the momentum the BEV transition has built in recent years. Although the new law eliminates the EV tax credit for consumers, which can dampen consumer adoption, it only makes changes to the battery manufacturing tax credit program under Section 45X without eliminating it. It is not yet fully clear how the various provisions of the new law will impact the US EV industry. A survey of car buyers in May 2025 found that one in four vehicle shoppers are "very likely" to consider buying an EV and 35 percent are "somewhat likely"—numbers that remain unchanged compared to the previous year's survey (Marshall 2025). Automakers are also keen to push for regulations that can support their EV investments and commitments (Davenport and Ewing 2024). Policymakers are interested in ensuring that changes in EV policies do not create adverse impacts on domestic manufacturing and jobs (Domonoske 2025). As shown in Figure 5 (and discussed more in "Implications of the BEV transition for automotive manufacturing jobs, skills, and occupations"), multiple states are already receiving billions of private EV manufacturing investments, and state and local officials are motivated to protect their burgeoning ties with the EV industry.

FIGURE 5 | Announced EV manufacturing investments



Note: The map shows announced private investments for battery and electric vehicle (EV) manufacturing facilities since January 2021. Data for battery manufacturing facilities in the US Department of Energy (DOE) data set include minerals extraction and processing, battery component manufacturing, battery cell manufacturing, and battery pack manufacturing. Data for EV manufacturing facilities include battery EVs and plug-in hybrid EVs and cover vehicle assembly, vehicle components, and vehicle chargers. DOE's data set only reports data on investment amounts if they have been publicly announced in sources like direct company announcements, governmental sources, and news outlets, among others (DOE 2025). Announced private investment data shown here were collected in February 2025.

Source: DOE 2025.

Implications of the BEV transition for automotive manufacturing jobs, skills, and occupations

Drawing primarily on a survey of automotive manufacturing firms and stakeholder interviews and supported by secondary data analysis, this section discusses the results and key takeaways with respect to changing skills for automotive manufacturing workers. The section also presents findings related to how the BEV transition is perceived by automotive manufacturers as well as considerations around job quality and inclusivity of the workforce.

The automotive industry's transition to large-scale production of BEVs brings with it changes in skills for workers—requiring an increasing focus on understanding which skills will be obsolete and which will be in demand—and investments in reskilling and upskilling to close future gaps in workforce capabilities.[13] In addition, the emerging geography of BEV production and job quality considerations are other issues that have implications for jobs, skills, and opportunities in the context of the BEV transition.

A small subset of OEMs and Tier 1 industries will likely face significant disruption, but there are transition opportunities even for the most vulnerable occupations

This section highlights particular industries and workers that are most at risk of disruption or displacement through the BEV transition and examines the transition potential for the most at-risk workers.

Workers in gasoline engine and engine parts manufacturing will see the most disruption or a decline in demand for their work. The analysis in this section is based on classification of 10 different NAICS codes representing OEMs and Tier 1 automotive manufacturing industries into three categories based on their risk of workforce disruption: significant disruption, moderate disruption, and minimal disruption (see Table 3 in "Research methods"). About 7 percent (58,023) of workers in OEMs and Tier 1 industries are in gasoline engine and engine parts manufacturing (NAICS 336310), which is the industry likely to see the most volatility because it manufactures ICEV-specific components.

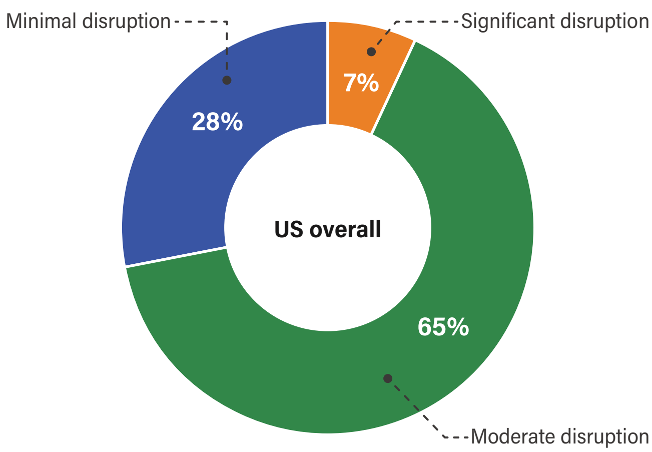
Some moderate impacts are also likely within industries that compose 65 percent of OEM and Tier 1 employment (574,388 workers) as components and manufacturing processes undergo changes from the status quo; these industries will likely not face widespread disruption to their product lines or processes (Figure 6). For example, one analysis that included interviews of production workers and technicians found that ICEV transmission workers (NAICS 336350) should be able to adjust to the tangible differences of BEV transmissions (Cotterman et al. 2022).[14] This is because there are overlaps in the range of skills required for manufacturing ICEV power train components, such as transmissions, and EV power train components. While existing workers have transferable skills, they will still need upskilling to work on single-speed transmissions in BEVs compared to multispeed gearboxes in ICEVs. Workers will also need to understand how new systems in BEVs, such as a battery pack, electric motor, and power electronics, integrate with the transmission.

Some occupations within gasoline engine and engine parts manufacturing are likely to face the most disruption, but other occupations within this industry are likely to see demand increase in other parts of the automotive industry. For instance, occupations such as engine and machine assemblers in this industry are most at risk because they are expected to see a decline in employment across all industries, whereas various engineering occupations are projected to see strong demand growth in other parts of the economy, as shown by US Bureau of Labor Statistics (BLS) employment projections[15] and the survey of automotive manufacturing firms.

KEY TAKEAWAY

Most current manufacturing workers will face moderate disruption (e.g., transmission parts and brake manufacturing workers), but only a small subset of workers in OEMs and Tier 1 industries will likely face significant disruption (e.g., gasoline engine and engine parts manufacturing workers) or even a net decline in demand for their work. Even for the most at-risk occupations within this subset, there are transition opportunities in BEV manufacturing and adjacent industries that require similar skill sets.

FIGURE 6 | Share of employment within OEMs and Tier 1 automotive industry by risk of workforce disruption



Note: Although exhaust systems are specific to internal combustion engine vehicles and should fall under "Significant disruption," currently there is no North American Industry Classification System (NAICS) code that depicts exhaust system manufacturing specifically as this vehicle component is captured under NAICS 336390 (Other Motor Vehicle Parts Manufacturing). Therefore, no precise data are available for the number of workers solely dedicated to manufacturing exhaust systems, preventing the inclusion of workers involved in exhaust system manufacturing under "Significant disruption." OEM = original equipment manufacturer.

Source: Authors, using BLS 2023d and US Census Bureau 2025.

Having identified the industries likely to face the greatest disruption, the research team then examined the most common manufacturing occupations within the gasoline engine and engine parts manufacturing (NAICS 336310) industry.[16] The BLS expects demand for several occupations within the gasoline engine and engine parts manufacturing industry, including production occupations such as electrical and electronic assemblers; welders, cutters, solderers, and brazers; and machine tool operators (Table 6) as well as different engineering occupations (Table 7),[17] to increase in industries beyond gasoline engine and engine parts manufacturing over the next 10 years. In contrast, other production occupations that include workers who assemble or rebuild engines are likely to see a decline in employment in other parts of the economy as well, leaving these workers within the gasoline engine and engine parts manufacturing industry with fewer direct transition opportunities elsewhere.

Complementing the BLS projections, survey responses from automotive manufacturing firms involved with ICEV assembly, ICEV component parts (i.e., engines, transmissions), or ICEV subcomponent parts (i.e., pistons, differential, gear sets) also indicate that assemblers are the most likely to face job disruptions during the transition (Figure 7). Assemblers

TABLE 6 | Key production occupations within gasoline engine and engine parts manufacturing and their employment outlook

SOC CODE	SOC DESCRIPTION	Q3 2023 EMPLOYMENT IN NAICS 336310 (IN THOUSANDS)	Q3 2023 ECONOMY-WIDE EMPLOYMENT (IN THOUSANDS)	10-YEAR PROJECTED ECONOMY-WIDE EMPLOYMENT (% CHANGE)
51-1011	First-Line Supervisors of Production and Operating Workers	2.4	700.8	0.0
51-2028	Electrical, Electronic, and Electromechanical Equipment Assemblers, Except Coil Winders, Tapers, and Finishers	1.4	260.6	5.6
51-2031	Engine and Other Machine Assemblers	2.9	38.6	-21.1
51-2092	Team Assemblers	12.4	1254.3	0.1
51-2099	Assemblers and Fabricators, All Other	1.5	256.5	1.4
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	3.3	181.3	-11.9
51-4041	Machinists	1.6	315.7	0.1
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	0.9	155.4	-3.4
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	1.8	128	1.2

TABLE 6 | Key production occupations within gasoline engine and engine parts manufacturing and their employment outlook (cont.)

SOC CODE	SOC DESCRIPTION	Q3 2023 EMPLOYMENT IN NAICS 336310 (IN THOUSANDS)	Q3 2023 ECONOMY-WIDE EMPLOYMENT (IN THOUSANDS)	10-YEAR PROJECTED ECONOMY-WIDE EMPLOYMENT (% CHANGE)
51-4111	Tool and Die Makers	1.2	56.8	-12.3
51-4121	Welders, Cutters, Solderers, and Brazers	1.4	445.1	2.4
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	2.4	591.1	-3.1
51-9161	Computer Numerically Controlled Tool Operators	0.9	175.3	-11.3

Note: The authors used the industry-occupation matrix from the Bureau of Labor Statistics (BLS) to identify common occupations within specific North American Industry Classification System industries based on the BLS Standard Occupational Classification (SOC) framework. This table shows production occupations (classified under SOC 51-0000) within gasoline engine and engine parts manufacturing and their economy-wide employment outlook over the next 10 years. Occupations that have declining economy-wide employment projections are highlighted in red, and occupations that have increasing employment projections are highlighted in green in the last column. Q3 = third quarter.

Source: Authors, using BLS 2023a, 2023c.

TABLE 7 | Key engineering occupations within gasoline engine and engine parts manufacturing and their employment outlook

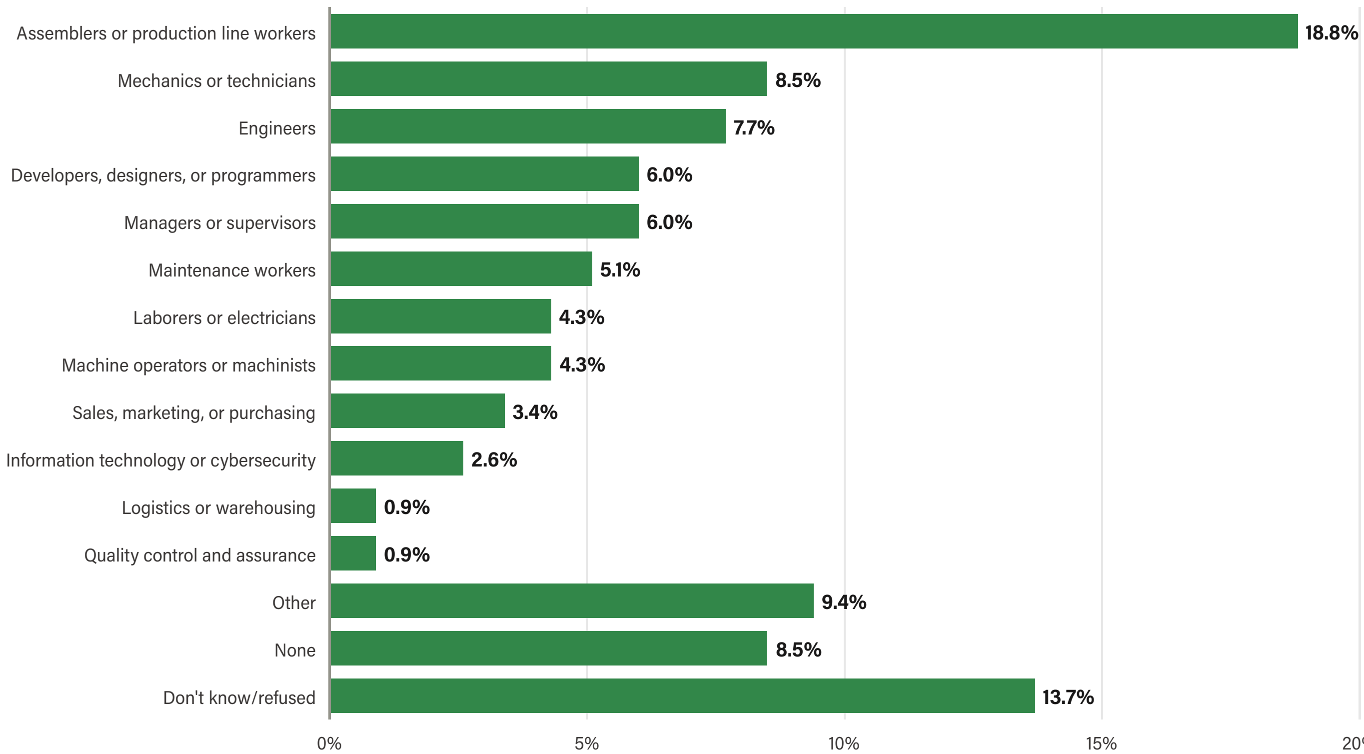
SOC CODE	SOC DESCRIPTION	Q3 2023 EMPLOYMENT IN NAICS 336310 (IN THOUSANDS)	Q3 2023 ECONOMY-WIDE EMPLOYMENT (IN THOUSANDS)	10-YEAR PROJECTED ECONOMY-WIDE EMPLOYMENT (% CHANGE)
17-2112	Industrial Engineers	1.7	343.0	11.4
17-2141	Mechanical Engineers	0.8	290.3	9.9
17-3026	Industrial Engineering Technologists and Technicians	0.5	75.4	2.3
17-3027	Mechanical Engineering Technologists and Technicians	0.2	39.8	-0.1

Note: The authors used the industry-occupation matrix from the Bureau of Labor Statistics (BLS) to identify common occupations within specific North American Industry Classification System industries based on the BLS Standard Occupational Classification (SOC) framework. This table shows engineering occupations (classified under SOC 17-0000) within gasoline engine and engine parts manufacturing and their economy-wide employment outlook over the next 10 years. Occupations that have declining economy-wide employment projections are highlighted in red, and occupations that have increasing employment projections are highlighted in green in the last column. Q3 = third quarter.

Source: Authors, using BLS 2023a, 2023c.

play a crucial role in the entire automotive manufacturing process, focusing on the meticulous assembly of vehicles and various components by ensuring that each component aligns with stringent quality standards and engineering specifications. Within gasoline engine and engine parts manufacturing, assemblers are involved in building, testing, and repairing internal combustion engines and component parts according to detailed specifications. The declining need for assembly of complex internal combustion engine components means that the BEV transition could lead to job displacement for assemblers. This same group of survey respondents also identified mechanics or technicians; engineers; and developers, designers, or programmers as roles likely to face some challenges. However, approximately one in seven survey respondents (13.7 percent) were unsure of the occupational impacts of the ICEV-to-BEV transition, which hints that some firms are still assessing emerging impacts and strategies to navigate the transition.

FIGURE 7 | What occupations are most likely to have the most difficult time transitioning from ICEVs to BEVs?



Note: N (number of responses) = 117. This survey question was asked to a subset of respondents who mentioned they were involved with internal combustion engine vehicle (ICEV) assembly, ICEV component parts (i.e., engines, transmissions), or ICEV subcomponent parts (i.e., pistons, differential, gear sets).

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

Battery manufacturing presents significant opportunities to employ the most vulnerable occupations within gasoline engine and engine parts manufacturing. Among the adjacent industries identified (see Table D-3 in Appendix D), the battery manufacturing industry in particular will increasingly play a prominent role as the ICEV-to-BEV transition takes place. Four vulnerable occupations (from Table 6) within gasoline engine and engine parts manufacturing are projected to see notable growth within the battery manufacturing (NAICS 335910) industry (Table 8). These are production occupations that can be found in gasoline engine and engine parts manufacturing as well as battery manufacturing. For instance, team assemblers assemble various gasoline engine components within gasoline engine and engine parts manufacturing; in battery manufacturing, their role involves assembling battery components according to specifications and ensuring quality control. Using the DOE's EV battery demand estimates and McKinsey's projected workforce demands per gigawatt hour of battery production per year, this report projects that there could be as many as 80,000 jobs within the battery manufacturing industry by 2032 (Campagnol et al. 2022; DOE 2023).[18]

Assuming the composition of various occupations within battery manufacturing follows existing staffing trends, the battery industry could provide significant employment opportunities (these occupations may not always be in the same geographic location—a challenge discussed later in this section), especially for many of the most at-risk displacement occupations within gasoline engine and engine parts manufacturing because of overlaps in skill sets (SME n.d.a). According to this report's analysis, by 2032, team assembler jobs in battery manufacturing could potentially offset jobs lost by 63 percent of the team assemblers currently working within the gasoline engine and engine parts manufacturing industry. Engine and other machine assemblers (SOC 51-2031), however, lack a direct occupational counterpart within the battery manufacturing industry.

TABLE 8 | Transition opportunity for at-risk occupations within motor vehicle gasoline engine and engine parts manufacturing in battery manufacturing

SOC CODE	SOC DESCRIPTION	CURRENT EMPLOYMENT IN MOTOR VEHICLE GASOLINE ENGINE AND ENGINE PARTS MANUFACTURING (IN THOUSANDS)	BATTERY JOBS BY 2032[a] (IN THOUSANDS)	DIFFERENCE IN JOBS (IN THOUSANDS)	SHARE OF EXISTING JOBS MET BY NEW BATTERY JOBS (%)
51-2092	Team Assemblers	12.4	7.8	4.6	63
51-2099	Assemblers and Fabricators, All Other	1.5	1.0	0.6	63
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	3.3	0.7	2.5	22
51-9161	Computer Numerically Controlled Tool Operators	0.9	0.6	0.2	76

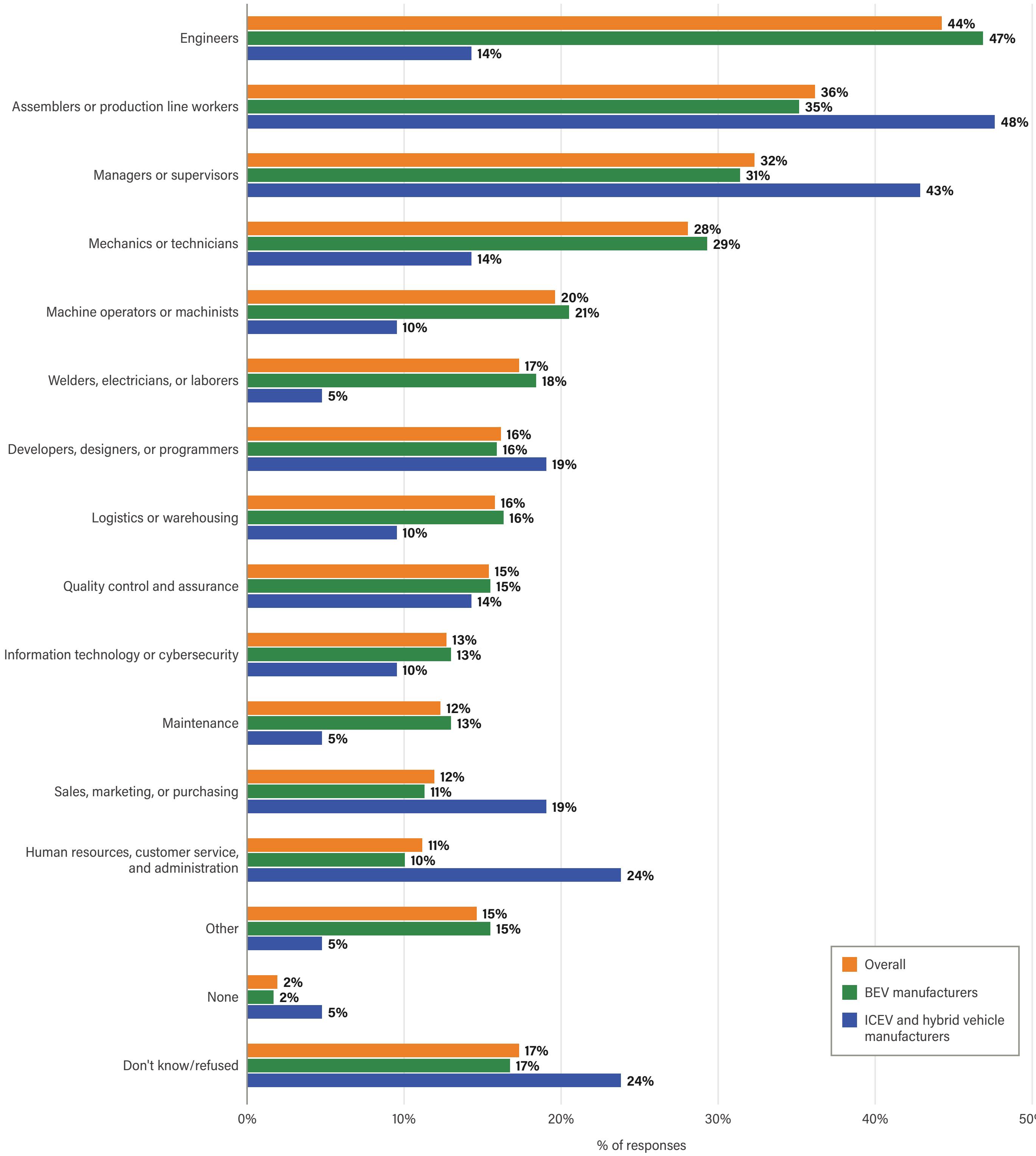
Note: [a.] Based on the US Department of Energy's battery deployment projected demand by 2032 and McKinsey's battery workforce estimates and staffing patterns.
Source: Authors, using BLS 2023a, 2023c; Campagnol et al. 2022; and DOE 2023.

Surveyed employers who noted they expect to see an increase in the size of their workforce over the next three years reported that assemblers or production line workers were the second-most likely occupation that growing firms expected to hire soon. Just over one in three (36 percent) growing firms expects to hire assemblers or production workers, and an even higher proportion (44 percent) of firms expects to hire engineers. Managers or supervisors and mechanics or technicians are also expected to see increased demand from automotive manufacturing firms, with 32 percent and 27 percent of survey respondents, respectively, indicating they would likely hire those roles in the next three years (Figure 8).[19] Among surveyed firms who are involved in BEV manufacturing and who expect to see a growth in their workforce, engineers (47 percent), assemblers or production line workers (35 percent), managers or supervisors (31 percent), mechanics or technicians (29 percent), and machine operators or machinists (21 percent) are some of the most common occupations expected to grow in demand.

The wages of workers in vulnerable occupations could be higher if they transition to new occupations with similar knowledge, skills, and abilities (KSAs). The research team mapped at-risk production occupations in the gasoline engine and engine parts manufacturing industry to occupations with similar KSAs (KSA-matching was based on the O*NET OnLine Related Occupations data set) and that were projected to grow by the BLS. These occupations are related to the development of software, electrical equipment, and industrial materials, including those involved in battery production. Table 9 shows that the economy-wide projected growth rates for occupations with similar KSAs for five vulnerable occupations within motor vehicle engine and engine parts manufacturing range from +1.2 percent to +5.6 percent.

Researchers then looked at differences in wages between the vulnerable occupations in gasoline engine and engine parts manufacturing and occupations in adjacent industries with similar KSAs. Only two of the five occupations have wages that are not higher in the new occupation with similar KSAs (Table 9). For instance, there is significant overlap in skills between team assemblers on one hand and electrical, electronic, and electromechanical equipment assemblers on the other hand, especially in terms of requiring foundational assembly skills. These skills include proficiency in use of tools, manual dexterity and precision, and the ability to read technical drawings and blueprints. The key difference lies in more specialized technical skills for electrical equipment assembly. This means that although transitioning to these similar occupations is possible, it will require upskilling for greater technical expertise or machine operation, which could be a factor contributing to higher wages.

FIGURE 8 | What are the top five occupations your firm will hire?



Note: N (number of responses) = 260. This survey question was answered by all respondents who noted they expect to see an increase in the size of their workforce over the next three years. BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for BEVs, BEV battery packs or materials, and BEV charging stations.

TABLE 9 | Occupations in adjacent industries with similar KSAs that provide transition opportunities for vulnerable occupations in gasoline engine and engine parts manufacturing

VULNERABLE OCCUPATIONS IN NAICS 336310 (SOC)[a]	OCCUPATIONS IN ADJACENT INDUSTRIES WITH GROWTH POTENTIAL (SOC)[b]	10-YEAR PROJECTED ECONOMY-WIDE EMPLOYMENT (% CHANGE)	AVERAGE ANNUAL WAGE	MEDIAN WAGE	75TH PERCENTILE WAGE
51-2092: Team Assemblers	51-2028: Electrical, Electronic, and Electromechanical Equipment Assemblers, Except Coil Winders, Tapers, and Finishers	5.6	↑	↑	↑
51-2031: Engine and Other Machine Assemblers			↓	↓	↓
51-2099: Assemblers and Fabricators, All Other			↑	↑	↑
51-4031: Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	51-4081: Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	1.2	=	=	↑
51-9161: Computer Numerically Controlled Tool Operators	51-4121: Welders, Cutters, Solderers, and Brazers	2.4	↑	↑	↑

Notes: O*NET OnLine's "related occupations" are developed using task-based and detailed work activity–based similarity, knowledge importance similarity, and alternate title similarity data. The last three columns show changes in wage if workers in vulnerable occupations in NAICS 336310 were to move to occupations in adjacent industries with growth potential. KSA = knowledge, skills, and abilities; NAICS = North American Industry Classification System; SOC = Standard Occupational Classification; [a.] Examples of mechanically intensive production occupations within gasoline engine and engine parts manufacturing; [b.] Occupations that are expected to see an increase in employment in adjacent industries and are similar in knowledge, skills, and abilities as production occupations in column 1.

Source: Authors, using BLS 2023a, BLS 2023c, and DOL ETA n.d.a.

The BEV transition will increasingly require new digital, advanced manufacturing, and specialized skills

This section identifies emerging skills and training needs within BEV manufacturing and argues that incumbent workers in legacy automotive manufacturing will likely need to upskill and reskill their KSAs to successfully transition into emerging opportunities within BEV manufacturing.

Major differences in KSAs between BEV and ICEV manufacturing roles are found in electric motor assembly, battery assembly, and thermal management systems. Significant KSA overlaps exist in components common to both BEVs and ICEVs. However, the new technologies used in BEVs, particularly components with advanced electrical systems, require some new KSAs not found in the ICEV manufacturing process. BEV workers must be proficient with high-voltage safety best practices, battery architecture, thermal management systems, and fundamental differences in battery storage capacities (due to differences in battery energy densities and battery pack configurations), among other core competencies (SME n.d.a, n.d.b).

This means that, even though opportunities exist to transition workers engaged in the most vulnerable occupations in ICEV manufacturing to newer occupations in adjacent industries (including battery manufacturing), the transition will not happen on its own. Substantial investments in upskilling and reskilling are needed, moving from mechanical-focused skills to a new curriculum centered on electrical, chemical, and software-based systems and an increased focus on safety protocols for high-voltage systems and chemical handling of batteries.

Although this analysis focuses on the transition from light-duty ICEVs to BEVs, stakeholder conversations revealed that additional differences in KSAs exist between consumer and heavy-duty EVs. Heavy-duty BEVs, such as trucks and buses, generally use the same technologies found in consumer BEVs; however, the additional torque loads required of heavy-duty BEVs and the larger scale of components used mean that workers must possess specialized knowledge of multiphase electric motors and high-torque power train systems (Chandler et al. 2017).

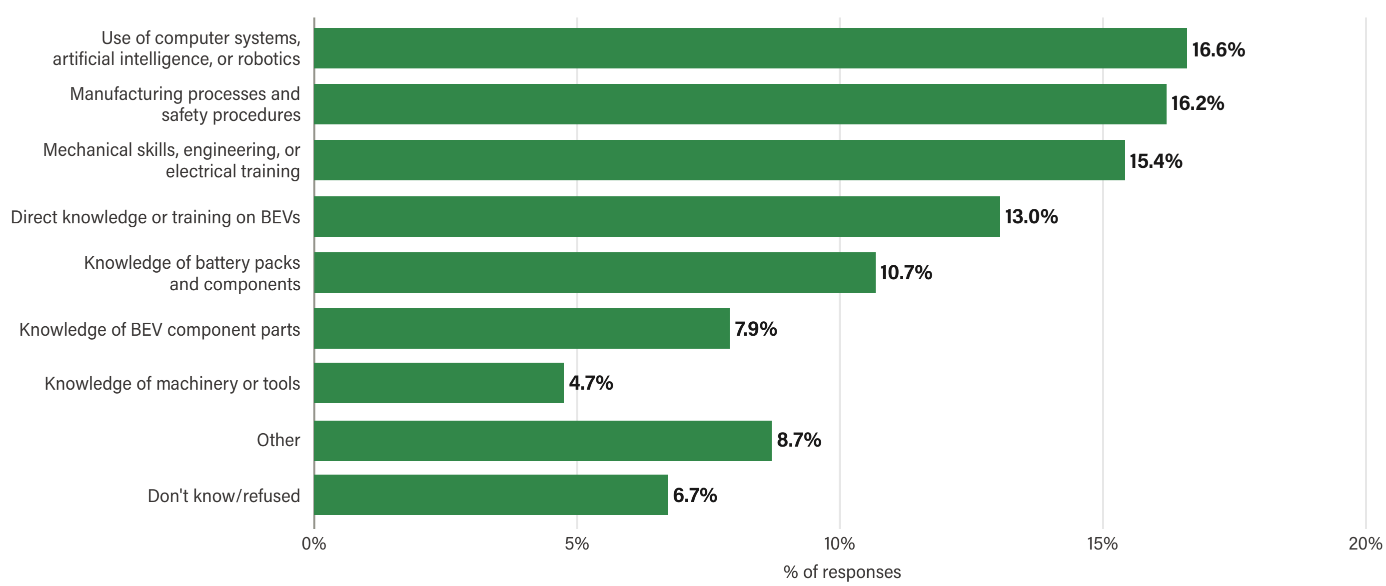
Charging station manufacturing workers must be familiar with electrical fundamentals, including circuits, voltage, and wiring; high-voltage systems; and various charging station components (charging port connectors, payment interfaces, power delivery cables, etc.). In particular, a deep understanding of electrical safety best practices is necessary due to the high-voltage systems involved. Charging station maintenance and repair workers must be familiar with the installation and maintenance of charging station components, in addition to software troubleshooting, site installation logistics, grid connectivity, and AC-to-DC power conversion principles (SAE 2024).

The need for knowledge of automated processes and systems goes together with the need for BEV-specific knowledge. Automation is significantly impacting automotive manufacturing, and the BEV transition is accelerating the adoption of automation due to the requirement of new manufacturing processes such as battery assembly and electric motor manufacturing. For instance, battery assembly entails high levels of accuracy and repeatability for placing individual cells, modules, and other components, making it a highly attractive area for automation. Furthermore, regardless of the pace of BEV adoption, upgrading workers' knowledge and ability to manage and troubleshoot more computerized or automated manufacturing processes is a top priority for automotive manufacturers as factories continue to update and upgrade machinery and production processes. Surveyed automotive manufacturing firms identified that in addition to knowledge specific to BEVs and engineering or manufacturing best practices, those currently working with ICEVs commonly needed reskilling to learn new computer and robotics systems (Figure 9).

KEY TAKEAWAY

Most additional knowledge needed falls into two categories: BEV-specific knowledge regarding high-voltage safety and battery manufacturing processes and the ability to handle increasingly automated manufacturing processes that are often introduced while factories upgrade or adjust production lines and processes for production of BEVs.

FIGURE 9 | What types of new BEV-specific knowledge or skills are required?



Notes: N (number of responses) = 253. BEV = battery electric vehicle.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

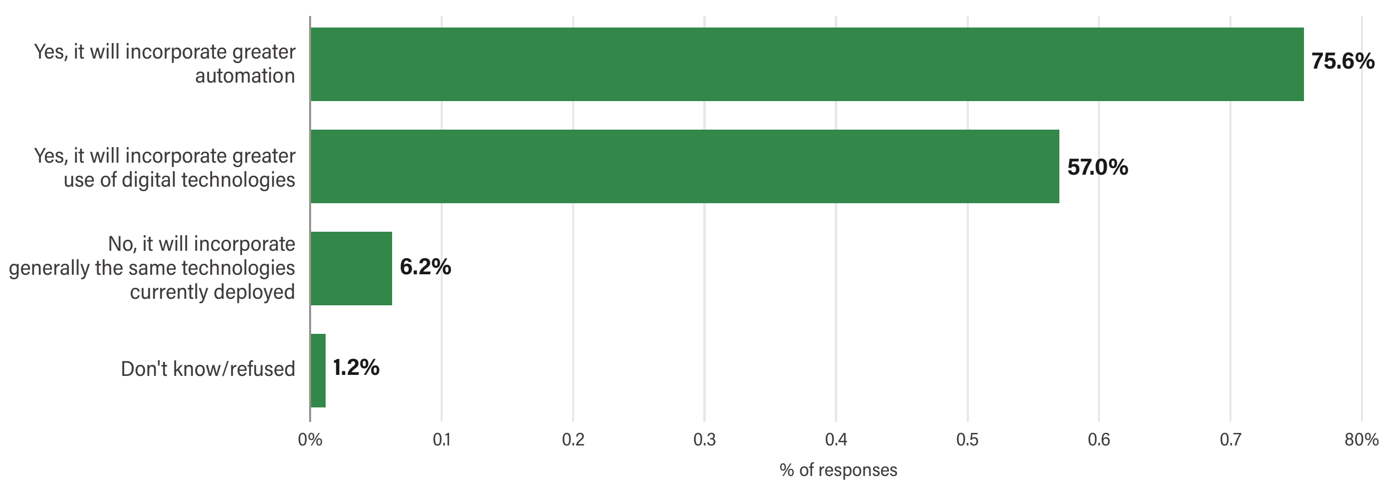
The need for these emerging skills is underscored by the fact that three in four survey responses (75.6 percent) reported new or expanded facilities will incorporate greater use of automated technologies.[20] Approximately one in two (57.0 percent) also expects new or expanded facilities to incorporate greater use of digital technologies[21] (Figure 10).

There is significant need to ramp up and spread training programs in response to the automotive industry's transition to BEVs. Automotive manufacturing firms are investing significantly in training programs to upskill and reskill incumbent workers as well as train prospective workers, but there is room for improvement across the industry. Nearly half (47.6 percent) of automotive manufacturing firms that responded to the survey directly offer training programs to both incumbent and prospective workers (Figure 11, panel a). Among these firms, over half (57.8 percent) offer on-the-job training programs, and 16.9 percent offer internships, apprenticeships, or boot camps (Figure 11, panel b).

Additionally, one in four firms (24.8 percent) have established formal partnerships with state agencies or local training or educational institutions to address their workforce training needs (Figure 12, panel a). These partnerships are primarily with local schools, colleges, and universities, with half (50.0 percent) of firms indicating as such; approximately one-fourth of firms partner with outside organizations and agencies (28.3 percent) and state agencies or workforce boards (20.0 percent) (Figure 12, panel b).

Partnerships and collaborations between leading manufacturers in the BEV industry and local institutions are an important feature of emerging BEV workforce training programs (Gowdy 2023; Saha et al. 2024b; Shrestha et al. 2025). In particular, large employers are working with institutions such as community colleges to develop apprenticeships and hands-on training opportunities to develop a skilled talent pipeline for the BEV industry. A few examples include Rivian's apprenticeship program in Georgia; Tesla's START program, which is available in eight states; Panasonic's workforce development program in Nevada; and GM's partnership with the American Association of Community Colleges, which integrates advanced manufacturing credentials into the college curriculum (AACC 2023; Kirkpatrick 2023; Rivian 2023; Tesla n.d.b).

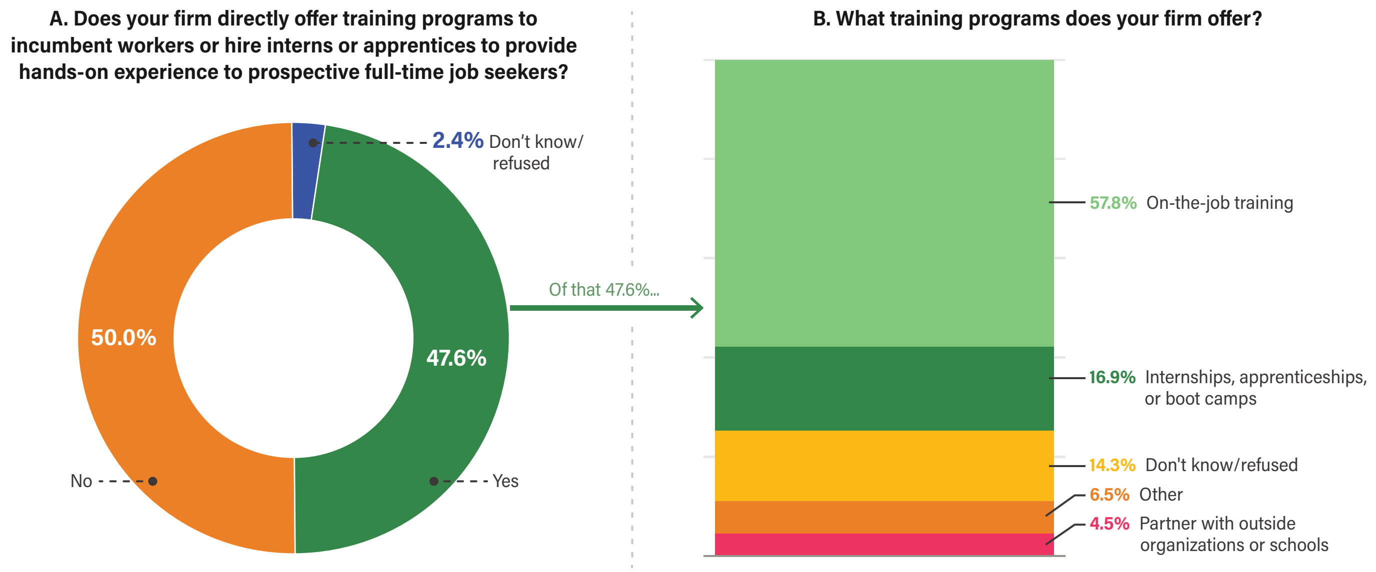
FIGURE 10 | Will your firm's new or expanded facilities incorporate new digital technologies or greater automation that previous locations did not have?



Notes: This survey question was only answered by respondents who said their firm is expanding the manufacturing capacity at the existing location or adding new locations. N (number of responses) = 258.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

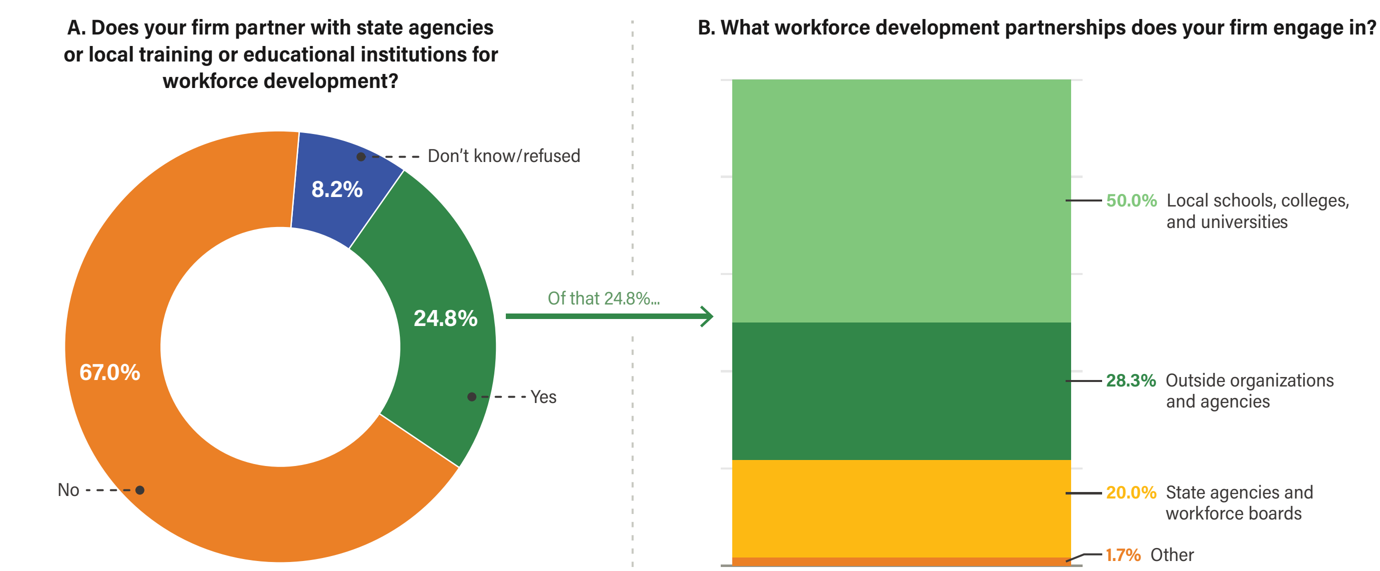
FIGURE 11 | How are automotive manufacturers providing workforce training programs?



Note: N (number of responses) = 330 (panel a), 154 (panel b).

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

FIGURE 12 | What types of workforce development partnerships are automotive manufacturers participating in?



Note: N (number of responses) = 330 (for left), 60 (for right).

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for battery electric vehicles (BEVs), BEV battery packs or materials, and BEV charging stations.

Although these are promising examples, the survey responses reveal that larger firms are more likely to have established such partnerships. Among respondents from firms with more than 250 employees, 28.8 percent said they have established partnerships with state agencies or local training providers, but this share is 10.5 percent among respondents with fewer than 50 employees. These trends indicate that smaller manufacturers have difficulty entering into successful partnerships with local institutions.

Several programs can provide a template for upskilling current ICEV workers for manufacturing BEVs and using advanced robotics systems. The Electric Vehicle Fundamentals Certification by the Society of Manufacturing Engineers (SME) focuses on the fundamentals of EVs, providing course enrollees with a comprehensive overview of the EV industry and EV manufacturing processes, in addition to modules covering industrial robotics manufacturing, quality control best practices, and essential workplace "soft skills" (SME n.d.b). The Electric Vehicle Battery Packaging and Assembly Certification course, also offered by SME, provides a detailed overview of lithium-ion battery packaging, assembly skills, and safety best practices in both battery assembly and end-of-life disposal (SME n.d.a).

SME also offers the Robotics in Manufacturing Fundamentals Certification course, which focuses on the fundamentals of manufacturing robotics, providing a starting point for career pathways in the advanced manufacturing industry (SME n.d.c). Another program oriented toward more automated manufacturing processes is the Robotics & Automation Technician Program offered by the Universal Technical Institute, which is designed to prepare students for entry-level careers, including as robotics and automation technicians, control systems technicians, and maintenance technicians. The course teaches electrical, mechanical, and programming skills, including programmable logic controller operation (UTI n.d.).

KEY TAKEAWAY

The BEV transition is rarely seen purely as an opportunity or as a threat. The industry has been growing, and most manufacturers are optimistic about future growth, particularly among firms already offering BEV or charger product lines. Employers seem to think about the transition as a reallocation of workers and resources rather than an outright displacement.

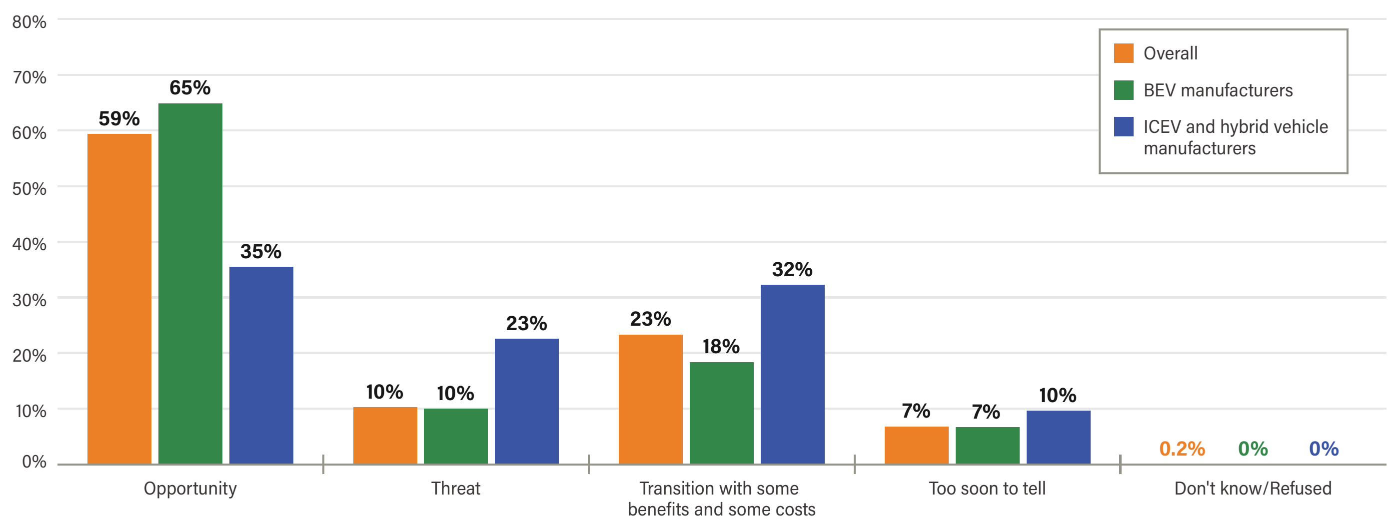
The BEV transition is mostly seen as an opportunity, though manufacturers see some downsides as well

This section outlines industry-wide and product line–specific transition perspectives, future growth expectations, and anticipated hiring challenges among key manufacturing roles. As noted in "Research methods," the survey was conducted in May–August 2024. It is possible that respondents' perceptions about the BEV transition may shift if the same survey were to be administered in 2025, after President Trump took office. Forthcoming policy changes on consumer tax credits, looser regulations to cut vehicle emissions, and tariffs on imported automobiles may pose a setback to the overall automobile industry and especially BEV makers. The full implications for BEV production and related impacts on automotive manufacturing workers remain to be seen as of the writing of this report.

The rise of BEVs is mostly seen as an opportunity. Over half (59 percent) of the automotive manufacturers surveyed see the transition to BEVs as an opportunity. Only 1 in 10 (10 percent) identified the transition as a "threat," and approximately 1 in 4 (23 percent) stated there would be trade-offs (Figure 13). The survey also revealed that automotive manufacturers that have not yet shifted to offering BEV products are more likely to feel threatened. Manufacturers only producing ICEV or hybrid vehicle products and subcomponents see the transition as a threat at a rate more than two times higher than manufacturers already producing BEV products and subcomponents.

While most manufacturers expect to grow over the next three years, BEV manufacturing firms were more likely to report expansion in production capacities. In the survey, approximately 70 percent of automotive manufacturing firms reported growth in 2023–24, with an even higher proportion of firms (82 percent) expecting to have more employees in the next three years. Nearly two in three (63 percent) manufacturers of BEV products indicated their firm was expanding capacity at existing locations, and approximately half (46 percent) indicated their firm was adding entirely new manufacturing locations. In contrast, ICEV and hybrid vehicle manufacturers reported lower rates of expansion at their firm compared to BEV manufacturers. Additionally, only 3 percent of BEV manufacturers indicated their firm was decreasing manufacturing capacity in the next year, compared to 16 percent of ICEV and hybrid vehicle manufacturers (Figure 14). Growth expectations in the near term may be tempered, but automakers are still signaling a change to BEVs in the long run (Cox Automotive 2025).

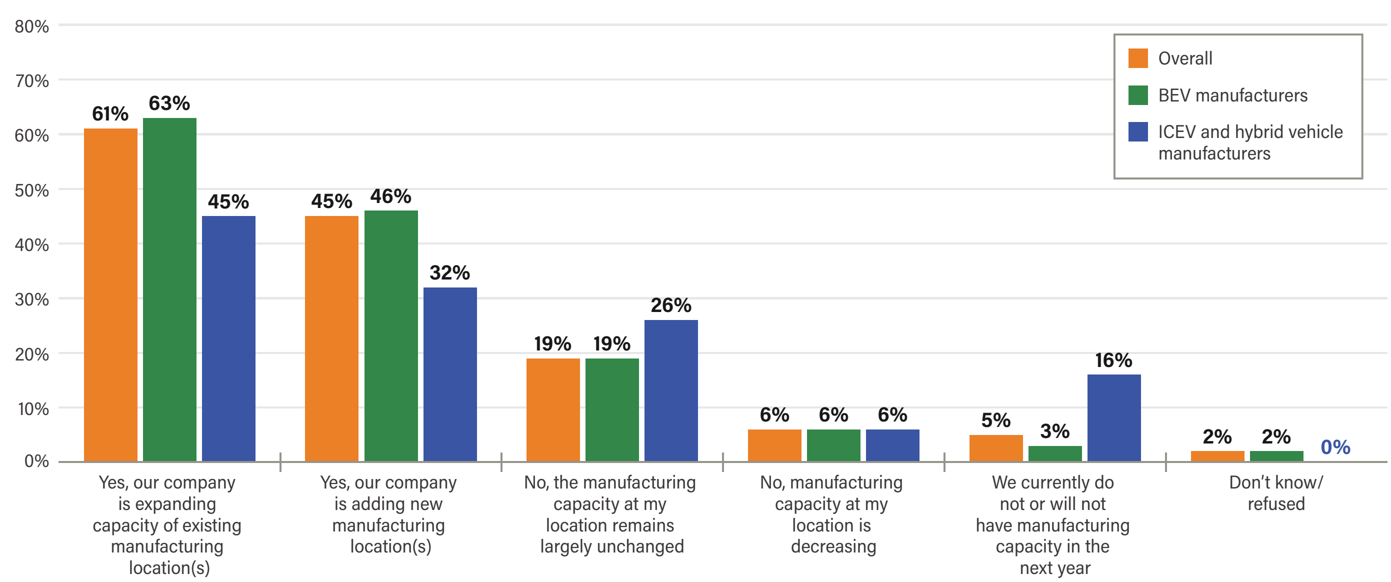
FIGURE 13 | Automotive industry perspectives of the BEV transition



Note: N (number of responses) = 330. BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for BEVs, BEV battery packs or materials, and BEV charging stations.

FIGURE 14 | Is your firm expanding manufacturing capacity at existing locations or adding new locations?



Note: Firms were able to provide multiple responses, so figures will sum to more than 100 percent. N (number of responses) = 330. BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.

Source: Authors, drawing on survey of automotive manufacturing firms producing finished or component goods for BEVs, BEV battery packs or materials, and BEV charging stations.

BEV manufacturing is occurring in both traditional automotive hubs and new manufacturing locations, creating a need for transition strategies and training programs based on different historical and geographical contexts

This section explores how the geographic spread of BEV manufacturing introduces transition challenges for workers involved in ICEV manufacturing, which is heavily concentrated in traditional automotive states. Using Georgia as an example, the report also identifies various factors behind the successful attraction of investments from automakers and battery suppliers.

There is a geographic mismatch between where vulnerable workers in ICEV manufacturing are or will be displaced and where new jobs in BEV manufacturing are emerging. BEV manufacturing is growing in traditional automotive manufacturing powerhouses, such as Michigan, and in new states with newly developed automotive manufacturing clusters, such as Georgia. As noted in Figure 14, 63 percent of BEV manufacturers are expanding the capacity of their existing manufacturing locations, and nearly half (46 percent) are adding entirely new manufacturing facilities. Transitioning to BEVs for workers within the same factory, county, or even state may not present a challenge, but workers in some states might not have an offsetting opportunity within the industry.

Workers in gasoline engine and engine parts manufacturing, in particular, may face such geographic challenges. Even if there are other offsetting BEV manufacturing opportunities, those opportunities may require relocation alongside investments in reskilling efforts. Factors such as family and community ties, housing affordability, and other preferences may lead to displaced or at-risk workers wanting to remain in their current locations. Figure 15 shows where most workers in this industry can be found and highlights that although much of this new investment into EVs and batteries is going to the same states, there are states other than traditional ICEV-manufacturing states that are receiving significant EV industry investments.

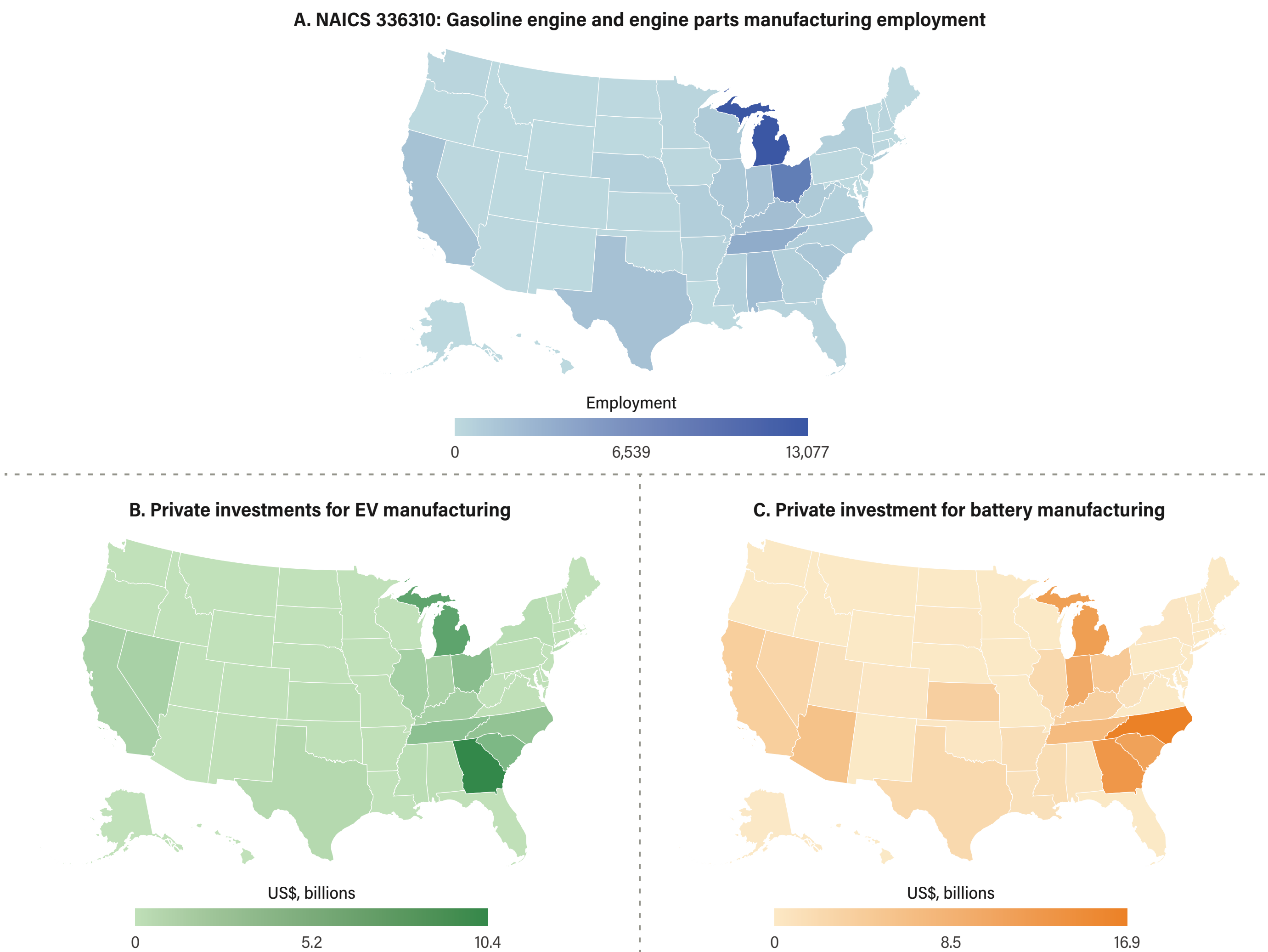
Wage differences within the same occupations across different states can pose transition challenges for displaced or at-risk automotive manufacturing workers; instead, the focus needs to be on retraining these workers in high-demand occupations in BEV manufacturing and adjacent industries. Michigan offers the highest wages for four of the seven key automotive manufacturing occupations among its peer states. Wages in these automotive manufacturing states are generally on par with, or slightly below, national averages (Table 10). Table 10 also highlights that, relative to costs of living, wages tend to be higher in Michigan, Ohio, and North Carolina. Moving to another state for a similar job can be unappealing if the pay is lower, hindering the personal well-being and career advancement of workers. Providing displaced or at-risk automotive manufacturing workers with retraining in high-demand occupations in BEV manufacturing, such as manufacturing batteries and electronics for BEVs, can increase the earning potential of these workers and make them more attractive to employers. Robust federal programs and cross-state partnerships, however, will be needed to provide retraining for workers shifting to BEV manufacturing in different locations.

A range of factors, including specialized training programs to develop a skilled workforce, are contributing to successful attraction of EV investments by US states. As of August 2024, the United States had emerged as a global leader in

KEY TAKEAWAY

BEV manufacturing is happening in both new and existing regions. Depending on a region's historical involvement with automotive manufacturing, different transition strategies will have to be deployed. Differences in geography will also have notable impacts for transitioning workers, primarily in compensation rates and training program availability. With BEV manufacturing spreading to new parts of the country, a slowdown or rollback of BEV adoption will hurt communities across the country, including in states such as Georgia and North Carolina, which have received billions in BEV investments and plan to be BEV manufacturing powerhouses.

FIGURE 15 | State-level comparison of gasoline engine and engine parts manufacturing employment and announced EV industry investments



Note: Employment data shown here are for the third quarter of 2023, and announced private investment data were retrieved in February 2025.
Sources: BLS 2023d; DOE 2025.

TABLE 10 | Wage differences for key automotive manufacturing occupations across states (third quarter of 2023)

SOC CODE	INCUMBENT OCCUPATION	GEORGIA WAGES	MICHIGAN WAGES	TENNESSEE WAGES	NORTH CAROLINA WAGES	OHIO WAGES	NATIONAL WAGES
51-2092	Team Assemblers	$45,300 (94%)	**$50,800 (120%)**	$49,400 (114%)	$43,300 (97%)	$48,700 (121%)	$51,400
51-2099	Assemblers and Fabricators, All Other	$47,800 (99%)	**$53,200 (126%)**	$52,400 (121%)	$45,100 (101%)	$50,900 (126%)	$54,400
51-2031	Engine and Other Machine Assemblers	$54,300 (112%)	$55,900 (133%)	$41,700 (97%)	**$69,800 (156%)**	$61,200 (152%)	$56,500
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	$46,900 (97%)	**$50,800 (120%)**	$45,600 (106%)	$47,200 (105%)	$48,800 (121%)	$50,300
51-4121	Welders, Cutters, Solderers, and Brazers	$42,800 (88%)	**$46,600 (110%)**	$42,300 (98%)	$46,000 (103%)	$44,200 (110%)	$47,400
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	$46,100 (95%)	$46,200 (110%)	**$47,300 (110%)**	$45,000 (100%)	$46,900 (116%)	$50,600
51-1011	First-Line Supervisors of Production and Operating Workers	**$71,800 (148%)**	$70,500 (167%)	$67,100 (155%)	$67,100 (150%)	$67,100 (166%)	$72,900
MIT Living Wage – 1 adult, no children		$48,448	$42,187	$43,196	$44,848	$40,359	--

Notes: A dark cell represents the state with the highest wage for a Standard Occupational Classification (SOC) occupation. The parenthetical percentages are the incumbent occupation wages relative to living wages, based on the Massachusetts Institute of Technology (MIT) Living Wage Calculator.

Sources: BLS 2023c; Glasmeier and MIT 2024.

attracting EV-related investments. Of the $1.2 trillion investments announced by automakers and EV battery manufacturers globally, the United States is expected to receive $312 billion in investment for EVs and EV battery manufacturing, whereas Europe and China are expected to receive $346 billion and $243 billion, respectively (Khatib 2024). Although provisions included in the IRA, such as tax credits and Domestic Manufacturing Auto Conversion Grants, and the Bipartisan Infrastructure Law have driven national investment, US states are competing to attract EV-related manufacturing investments. There are several factors that influence a company's decision to locate in one state versus another—including cost of living, favorable tax climates, access to talent and infrastructure, government incentives, and utilities cost—but stakeholders state that the availability of a skilled workforce is a key factor. Georgia provides a good example of how these various factors play out. Georgia is not a "legacy" automotive manufacturing state and has minimal historical participation in the automotive industry. Nonetheless, Georgia added or expanded 78 automotive manufacturing facilities over the past five years and attracted the second-highest number of EV-related IRA-funded projects (19 projects) among all states, trailing Michigan, a legacy automotive manufacturing state, with 24 projects (E2 2025 GDEcD n.d.a). Box 2 examines five key elements in Georgia's success in attracting new EV investments from both public and private entities.

BOX 2 | Investing in Georgia's electric future

Georgia is striving to be the "e-mobility capital of the world."[a] Hyundai's first electric sport utility vehicle, the IONIQ 9, is produced in Bryan County, Georgia. This is part of a $7.6 billion investment and counts as the largest economic development project in the state.[b] Including Hyundai's battery joint ventures with SK On and LG Energy Solution and investments announced by more than a dozen suppliers, Hyundai's new manufacturing facility has attracted over $12.6 billion in investments, which is estimated to create over 50,000 direct and indirect jobs in Georgia.[c] These are the key factors driving investments in Georgia:

- **Strong, existing workforce availability and workforce development pipelines.** Georgia's Quick Start workforce development program was the first initiative of its kind in the United States, providing no-cost training, upskilling, and reskilling services for firms in Georgia.[d] Georgia's Quick Start model operates on four principles: collaboration with companies, multimodal training development pathways, flexible and responsive training delivery, and intellectual property confidentiality.[e] Georgia also possesses a high concentration of training programs specific to electric vehicles (EVs).[f] Hyundai and Savannah Technical College have developed the Electric Vehicle Professional Technical Certificate of Credit, which prepares students for entry-level jobs in EV manufacturing.[g]
- **Financial incentive packages.** Georgia has provided a variety of sizable financial incentive packages to automakers, most notably the state's $1.8 billion incentive package—the largest incentive package in Georgia's history—for Hyundai's EV and battery manufacturing facility, with $117 million earmarked for workforce training programs.[g] Georgia also provided $1.5 billion in incentives for Rivian to build a $5 billion EV plant east of Atlanta. Announced in 2022, the incentive package's primary components are $700 million in property tax subsidies, $200 million in site development (site purchasing, grading, utility connectivity, etc.), and a $200 million income tax credit.[h]
- **Friendly regulatory environment.** Georgia also has numerous state-sponsored initiatives to accelerate new business activities and reduce regulatory burdens in the state, notably the Georgia Ready for Accelerated Development program, which assists companies in identifying optimal site locations and fast-tracks the construction permitting process.[i] Additionally, Georgia's Electric Mobility and Innovation Alliance initiative, led by the Georgia Department of Economic Development, is a public-private partnership created to support the growth of the entire electric mobility sector and foster innovation by creating a business-friendly environment for the industry and promoting favorable public policy.[j]
- **Existing supply chain infrastructure.** Georgia's Port of Savannah and Port of Brunswick provide firms with a well-established supply chain and logistics infrastructure, with the Port of Brunswick processing a record 775,000 units of automobiles and machinery in 2023, representing a 15.6 percent increase from 2022. Additionally, the Georgia Ports Authority will invest approximately $4.2 billion over the next 10 years to support site improvements, facility expansions, and cargo-handling capabilities, reaffirming the state's commitment to providing robust supply chain infrastructure to firms.[k] An additional $48.8 million was awarded to the Georgia Ports Authority by the US Environmental Protection Agency to deploy zero-emission infrastructure upgrades in 2024.[l]

  The Hartsfield-Jackson Atlanta International Airport is also a central component of Georgia's supply chain infrastructure for both commercial and passenger transportation. The airport was the world's busiest airport by passenger traffic in 2023, serving over 104 million passengers, and was the 13th busiest air cargo airport in the United States in 2020.[m]
- **Right-to-work (RTW) laws.** RTW laws refer to an employee's ability to work for an employer without joining a union or paying agency fees for representation that may otherwise be tied to that employer or a contract through that employer.[n] RTW is often considered a net benefit for employers and firms but erodes the power of labor unions and workers and can subsequently exert downward pressure on wages.[o] Georgia was an early adopter of RTW, implementing its RTW statute in 1947.[p] While RTW may offer employers greater flexibility and lower labor costs, it can also shape perceptions among prospective workers—particularly those in skilled or unionized trades—who may view the lack of collective bargaining power and wage protections as a deterrent to such labor markets.
- **High concentrations in adjacent manufacturing industries.** Georgia's high concentrations of adjacent manufacturing industries (i.e., Tier 2 and Tier 3 component manufacturers) further strengthen its value position relative to other states or locations. Measured through location quotients, Georgia shows strength in the following adjacent manufacturing industries (Table B2-1). When related industries cluster together, it fosters knowledge spillovers; promotes easier entry for new, related industries that can leverage existing infrastructure, skills, and supply chain; and encourages economies to diversify along pathways of "nearby" products and technologies.[q]

BOX 2 | Investing in Georgia's electric future (cont.)

TABLE B2-1. HIGHLY CONCENTRATED ADJACENT MANUFACTURING INDUSTRIES IN GEORGIA

NAICS CODE	ADJACENT MANUFACTURING INDUSTRY	GEORGIA LOCATION QUOTIENT (Q1 2024)	GEORGIA EMPLOYMENT (Q1 2024)
325510	Paint and Coating Manufacturing	1.73	2,271
326211	Tire Manufacturing (except Retreading)	1.64	2,721
326220	Rubber and Plastics Hoses and Belting Manufacturing	1.43	1,026
332510	Hardware Manufacturing	1.14	882

Notes: Location quotients are ratios used to assess the concentration for an industry group in a specific area relative to a larger geographic area (i.e., the United States). A location quotient greater than one here signifies an above-average concentration of those jobs in the region. NAICS = North American Industry Classification System; Q1 = first quarter.

Source: BLS 2023d.

Sources: [a.] Hansen 2024; [b.] Johnson 2025; [c.] Chen et al. 2023; [d.] GDEcD n.d.c; [e.] Georgia Quick Start n.d.; [f.] Gowdy 2023; [g.] Vining and Khatib 2024; [h.] Amy 2022; [i.] GDEcD n.d.d; [j.] GDEcD n.d.b; [k.] Georgia Ports Authority 2024; [l.] EPA 2024a; [m.] GDOT 2021; Port Authority of New York and New Jersey 2023; [n.] NCSL 2023; [o.] Dasgupta and Merchant 2023; [p.] GDOL n.d.; [q.] Baily and Montalbano 2017

The BEV transition presents an opportunity to improve wages and opportunity for all

This section highlights current workforce demographics within automotive manufacturing and discusses concerns related to job quality as the ICEV-to-BEV transition takes place. This section then compares the quality of existing roles and the types of roles that may grow more common in an increasingly automated industry as automakers introduce facility upgrades and transition to BEVs.

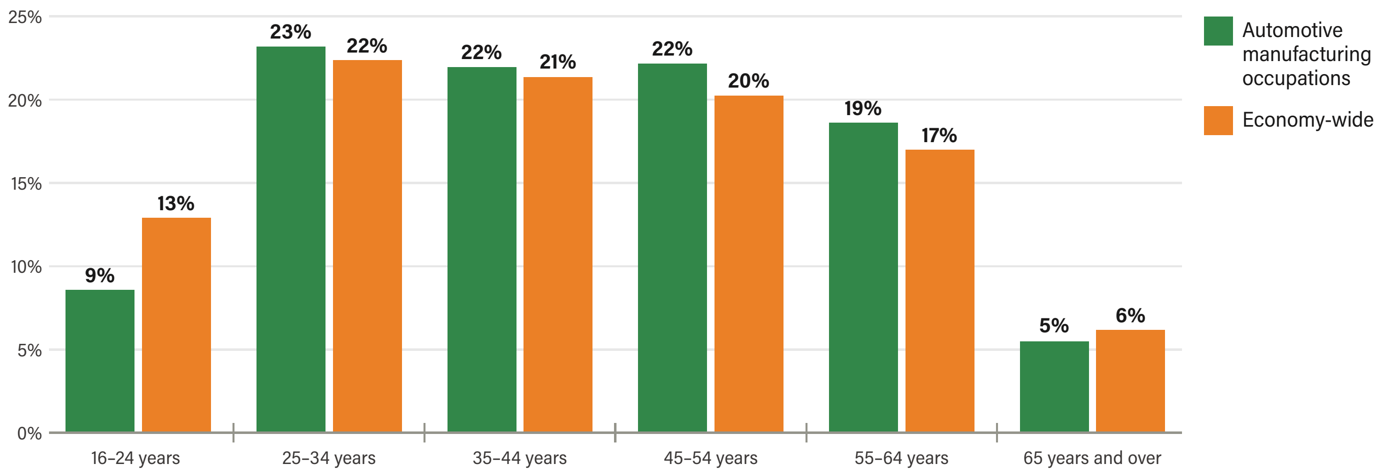
The need to hire new workers presents an opportunity to bring more workers of all backgrounds into the industry. The auto industry will need to attract and train many new workers into the workforce in the coming years. Roughly a quarter of the current automotive manufacturing workforce could be looking to retire over the next 10 years (Figure 16), raising concerns about a brain drain of institutional knowledge and labor shortages. These transitions introduce the possibility of bringing more workers of diverse backgrounds into the industry, including women, who currently account for 33 percent of workers within the top automotive industry occupations while making up roughly half of the US labor force (BLS 2023a). Black workers and workers with less than a bachelor's degree also stand to gain from an expansion of the BEV industry given their higher participation in the automotive manufacturing industry compared to the rest of the economy: Black workers account for 12.8 percent of workers economy-wide but 18.0 percent in automotive manufacturing as of 2023 (Table 11).[22] Workers without a four-year degree account for 62.2 percent of workers economy-wide but 74.6 percent in automotive manufacturing based on a 2021 study (Barrett and Bivens 2021). Increasing the accessibility of and interest in employment opportunities in automotive manufacturing is crucial to sustaining future growth in the industry.

Concerns regarding job quality and union negotiating power persist as the ICEV-to-BEV transition happens. Jobs in automotive manufacturing were once a ticket to the middle class in America, offering good wages and benefits. However, automotive manufacturing workers have seen a significant decline in wages (Figure 17), working conditions, and bargaining power over the last few decades due to multiple factors, including offshoring, economic shocks, temporary or contract labor, and rising automation (Barrett and Bivens 2021; Saha et al. 2024a). Although the reasons for this are complex and nuanced, the geographic expansion of automotive manufacturing has played a role, with many automotive companies setting up facilities in southern states to take advantage of cheaper, nonunion labor and/or moving facilities overseas (Figure 18).

KEY TAKEAWAY

The BEV transition presents an opportunity to increase access to historically high-quality jobs with higher wages for job seekers of all backgrounds. At the same time, the transition has prompted concerns about job quality and union negotiating power in the automotive industry. Accelerated automation can have both benefits and challenges for job quality. Automation can minimize worker exposure to dangerous tasks and lead to the creation of higher-skilled roles that offer greater wages and benefits. However, automation could also drive worker displacement and expose workers to new types of safety risks.

FIGURE 16 | Age demographics of automotive manufacturing occupations compared to the overall economy



Note: The figure shows age data for occupations within original equipment manufacturer and Tier 1 North American Industry Classification System codes.

Source: BLS 2023a.

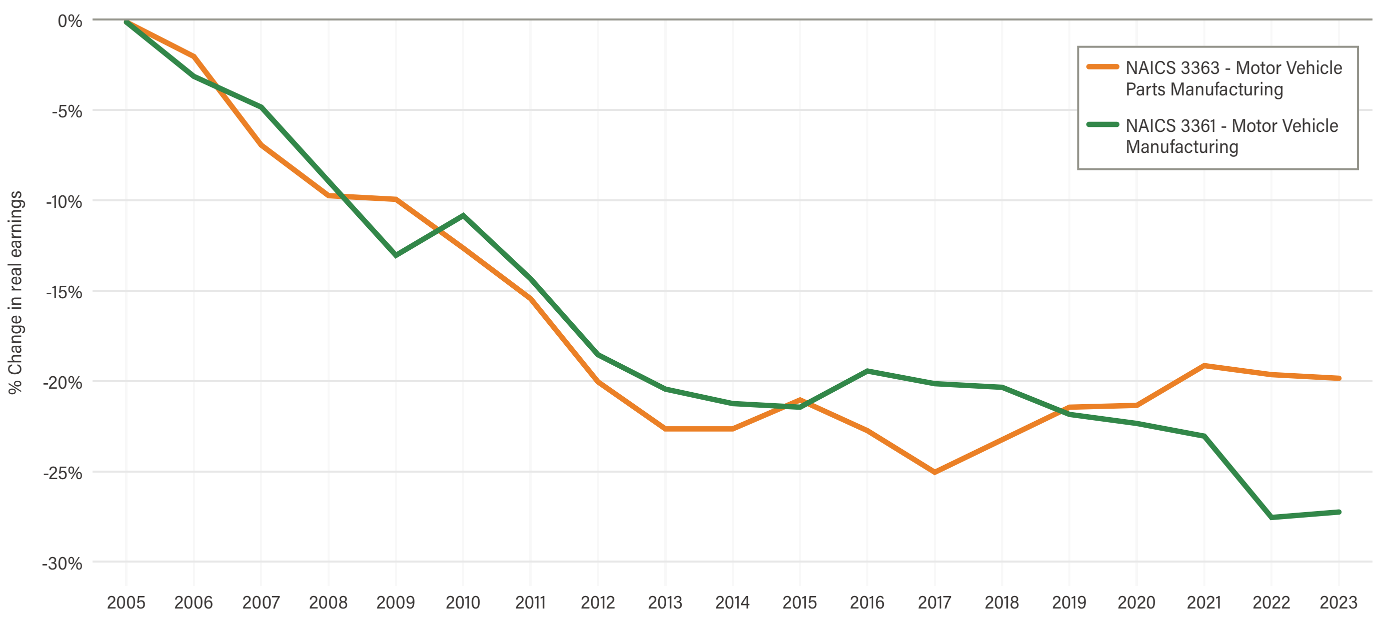
TABLE 11 | Key demographic characteristics of workers in motor vehicle manufacturing, manufacturing overall, and economy overall

	MOTOR VEHICLE MANUFACTURING (%)	MANUFACTURING OVERALL (%)	ECONOMY OVERALL (%)
Gender			
Male	73.6	70.5	53.1
Female	26.4	29.5	46.9
Race/ethnicity			
White	71.8	78.4	76.5
Black or African American	18.0	10.8	12.8
Asian	6.5	7.6	6.9
Hispanic or Latino	15.0	18.1	18.8
Union status			
Union	15.6	9.1	11.2
Education			
Less than high school	6.6	9.2	8.1
High school diploma/GED only	37.3	34.0	25.9
Some college	30.7	26.5	28.2
Bachelor's degree	17.2	21.0	24.1
Advanced degree	8.2	9.3	13.7

Notes: In this table, "Motor vehicle manufacturing" covers motor vehicle assembly and parts manufacturing. Manufacturing overall covers all manufacturing industries. Race/ethnicity data come from the Current Population Survey (CPS) of the US Bureau of Labor Statistics (BLS) and do not sum to 100 percent because people of Hispanic or Latino ethnicity are included in the white, Black or African American, or Asian race groups, in addition to being shown separately in BLS CPS data. See the BLS's CPS documentation for further details on sampling and nonsampling errors (BLS 2023b). GED = general equivalency diploma.

Sources: Barrett and Bivens 2021 (education data); BLS 2023b (gender and race/ethnicity data); Hirsch et al. 2024 (union status data).

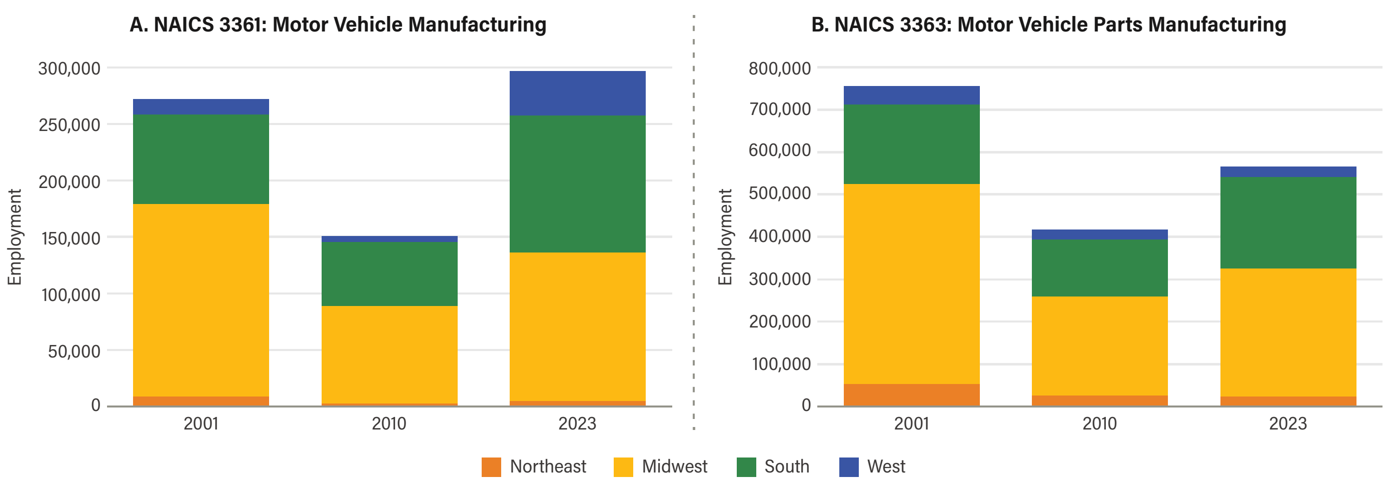
FIGURE 17 | Percentage change in real average hourly earnings in automotive manufacturing from 2005 levels



Note: Based on US Bureau of Labor Statistics data for production and nonsupervisory workers employed under two North American Industry Classification System codes: 3361 (Motor Vehicle Manufacturing) and 3363 (Motor Vehicle Parts Manufacturing).

Source: Saha et al. 2024a.

FIGURE 18 | Change in automotive manufacturing jobs by region

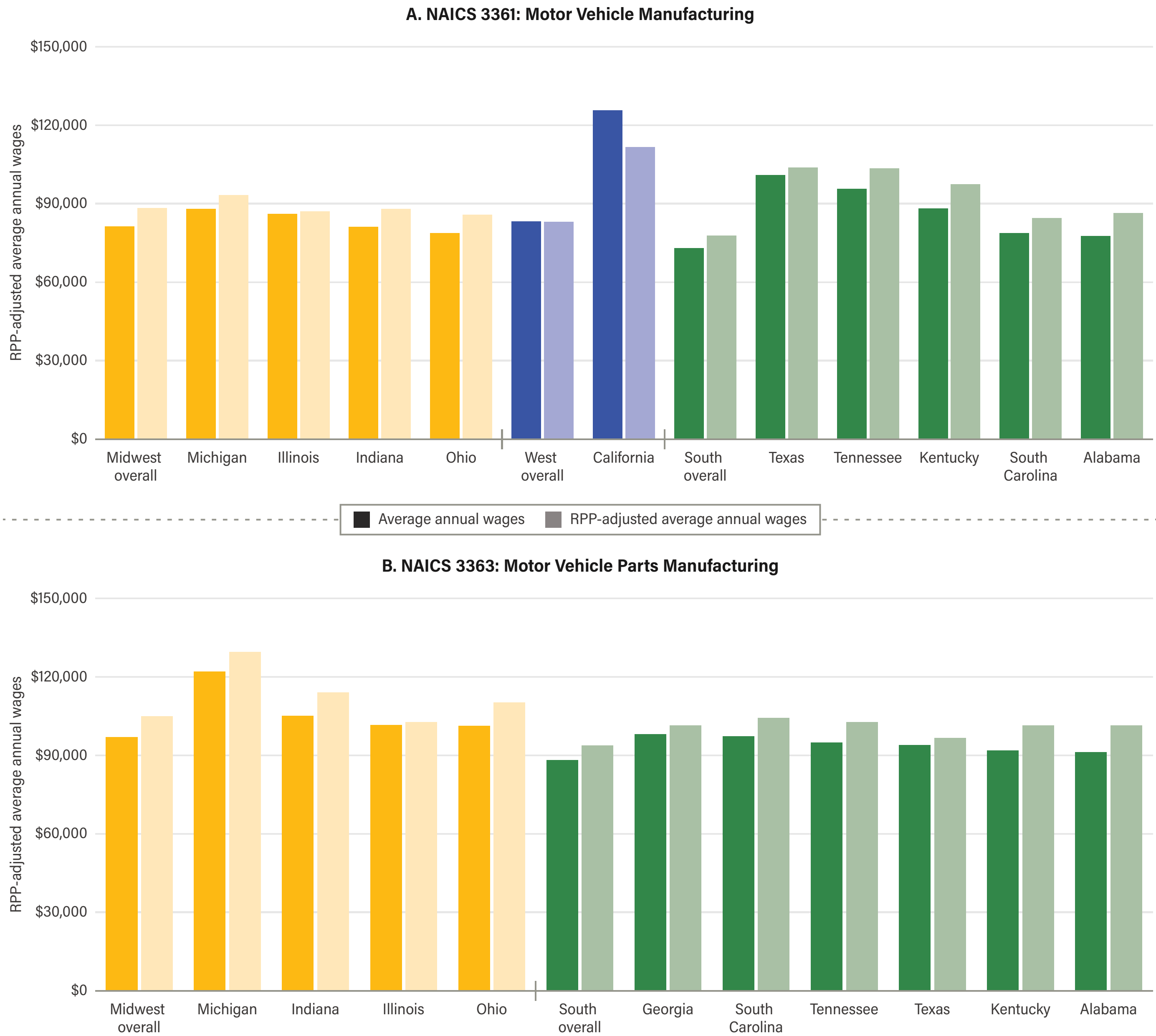


Source: Authors, using BLS 2023d.

The transition to BEVs can reinforce these regional patterns, especially since a significant portion of new investments in BEV manufacturing is going to southern states, which have right-to-work laws that make it difficult for workers to form unions and collectively bargain for better pay and working conditions (Chava et al. 2020; Childers 2024). Notably, unionized workers were able to leverage their bargaining power in late 2023 to force the "Big Three" automakers—Ford, GM, and Stellantis—to raise wages for the highest-paid workers by at least 25 percent over 4.5 years of the contract, raise wages for the lowest paid to at least $40 per hour by the end of the contract, restore cost-of-living increases, shorten the number of years it takes for employees to move to a higher pay grade, and increase contributions to their 401(k) plans (Chen 2024). Following the UAW deal with the Big Three, other nonunionized automakers, including Hyundai, Toyota, Volkswagen, and others, have said they will increase their wages too (Reuters 2023). Despite this, concerns remain that the UAW contract could further widen the current differences in wages between workers in the South and those in the Midwest as the terms of the new contracts are implemented (Figure 19).

Occupations that are more likely to grow as the industry automates offer higher wages than their corresponding incumbent occupation. The research team used the O*NET OnLine Related Occupations data set[23] and Degree of Automation data set[24] to identify occupations that have a higher day-to-day use and management of robotics and automated technologies than other existing occupations in the industry (DOL ETA n.d.a, n.d.b). The data suggest that most occupations that more frequently use automation and technology offer higher wages (Table 12). It is also noteworthy that identified automation-heavy occupation wages are generally higher than the Massachusetts Institute of Technology Living Wage standard for 1 adult with no children, and Georgia offers the highest wages for 5 of the 10 transition occupations among automotive manufacturing states (Table 13). This finding means that workers who are able to upskill and work with automation technologies at a greater capacity may be better off with new, higher-quality jobs. However, lower demand for workers overall means that additional support to find opportunities in related occupations within automotive manufacturing or adjacent industries will be necessary for workers who are not able to directly transfer to these more automation-oriented positions.

FIGURE 19 | Average annual earnings and cost-of-living adjusted earnings for workers in automotive manufacturing industries by region



Notes: The figure shows data for the top 10 states with the most employment in North American Industry Classification System (NAICS) code 3361 and NAICS 3363, respectively. RPP = regional price parity.

Source: Authors, using BLS 2023d and BEA 2024.

TABLE 12 | Comparing wages of vulnerable occupations in gasoline engine and engine parts manufacturing to wages of transition occupations with higher use of automation and technology (third quarter of 2023)

VULNERABLE OCCUPATION IN NAICS 336310 (SOC CODE)	WAGES OF VULNERABLE OCCUPATION (NATIONAL, US$)	TRANSITION OCCUPATION (SOC CODE)	TRANSITION OCCUPATION DESCRIPTION	TRANSITION OCCUPATION WAGES (NATIONAL, US$)
Team Assemblers (51-2092)	51,400	Electro-Mechanical and Mechatronics Technologists and Technicians (17-3024)	Operate, test, maintain, or adjust unmanned, automated, servomechanical, or electromechanical equipment; may assist engineers in testing and designing robotics equipment	71,000
Assemblers and Fabricators, All Other (51-2099)	54,400	Mechanical Engineering Technologists and Technicians (17-3027)	Apply theory and principles of mechanical engineering to modify, develop, test, or adjust machinery and equipment under direction of engineering staff or physical scientists	67,800
		Industrial Engineering Technologists and Technicians (17-3026)	Apply engineering theory and principles to problems of industrial layout or manufacturing production, usually under the direction of engineering staff	64,600
Engine and Other Machine Assemblers (51-2031)	56,500	Industrial Machinery Mechanics (49-9041)	Repair, install, adjust, or maintain industrial production and processing machinery or refinery and pipeline distribution systems	67,900
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic (51-4031)	50,300	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic (51-4081)	Set up, operate, or tend more than one type of cutting or forming machine tool or robot	49,300
		Tool and Die Makers (51-4111)	Analyze specifications, lay out metal stock, set up and operate machine tools, and fit and assemble parts to make and repair dies, cutting tools, jigs, fixtures, gauges, and machinists' hand tools	68,300
Welders, Cutters, Solderers, and Brazers (51-4121)	47,400	Computer Numerically Controlled Tool Operators (51-9161)	Operate computer-controlled tools, machines, or robots to machine or process parts, tools, or other work pieces made of metal, plastic, wood, stone, or other materials; may also set up and maintain equipment	48,500
		Computer Numerically Controlled Tool Programmers (51-9162)	Develop programs to control machining or processing of materials by automatic machine tools, equipment, or systems; may also set up, operate, or maintain equipment	60,800
Inspectors, Testers, Sorters, Samplers, and Weighers (51-9061)	50,600	Calibration Technologists and Technicians (17-3028)	Execute or adapt procedures and techniques for calibrating measurement devices, by applying knowledge of measurement science, mathematics, physics, chemistry, and electronics, sometimes under the direction of engineering staff	61,300
First-Line Supervisors of Production and Operating Workers (51-1011)	72,900	Industrial Production Managers (11-3051)	Plan, direct, or coordinate the work activities and resources necessary for manufacturing products in accordance with cost, quality, and quantity specifications	125,600

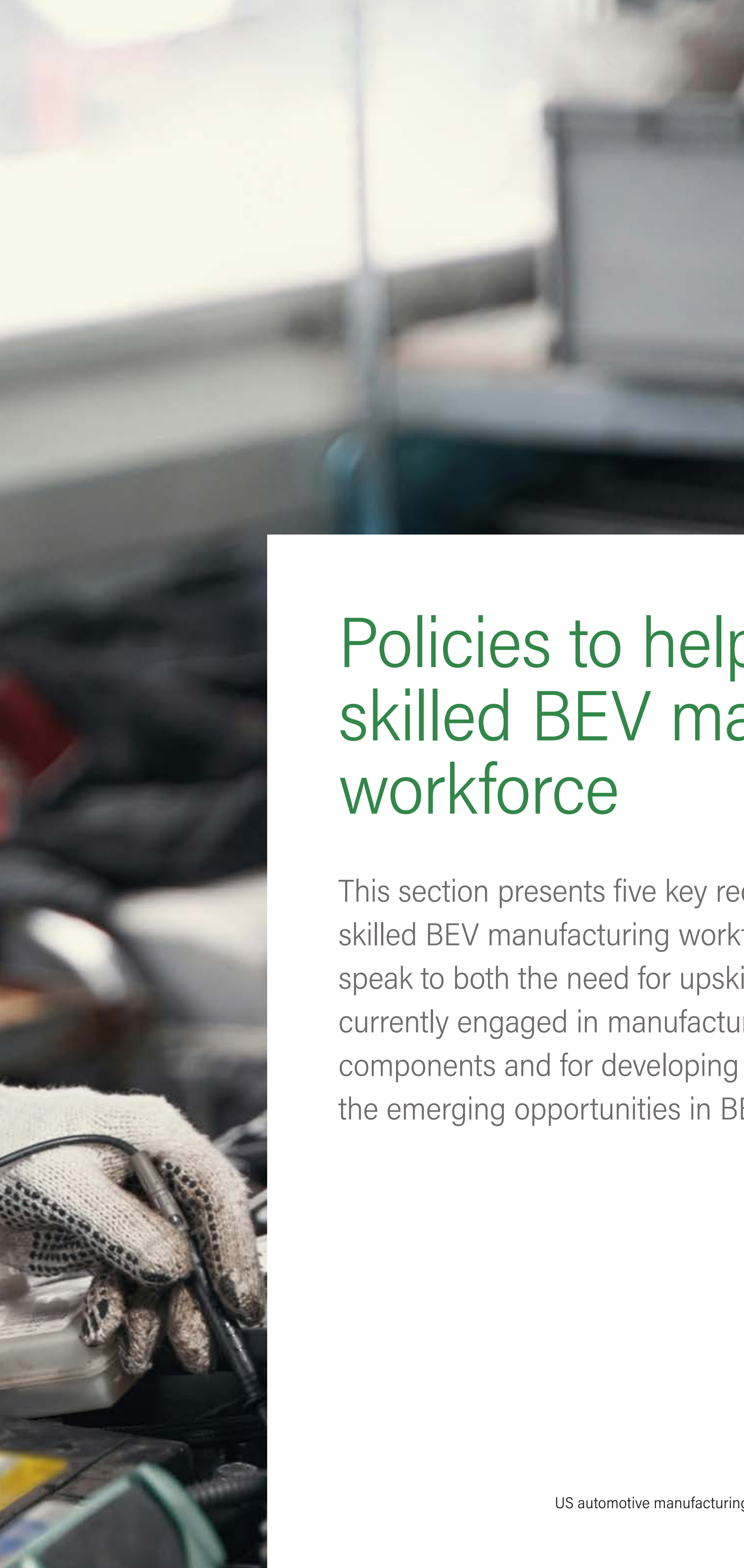
Note: SOC = Standard Occupational Classification.
Sources: BLS 2023c; DOL ETA n.d.a, n.d.b.

TABLE 13 | Transition occupation wages by geography (third quarter of 2023)

SOC CODE	TRANSITION OCCUPATION	GEORGIA WAGES	MICHIGAN WAGES	TENNESSEE WAGES	NORTH CAROLINA WAGES	OHIO WAGES	NATIONAL WAGES
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	**$68,500 (141%)**	$57,600 (137%)	$52,300 (121%)	$53,500 (121%)	$65,700 (163%)	$71,000
17-3027	Mechanical Engineering Technologists and Technicians	**$65,400 (135%)**	$63,200 (150%)	$63,200 (146%)	$59,700 (133%)	$65,700 (163%)	$67,800
17-3026	Industrial Engineering Technologists and Technicians	**$65,100 (134%)**	$61,900 (147%)	$58,600 (136%)	$60,400 (135%)	$59,600 (148%)	$64,600
49-9041	Industrial Machinery Mechanics	**$65,900 (136%)**	$64,900 (154%)	$61,000 (141%)	$64,400 (144%)	$65,500 (162%)	$67,900
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	$44,800 (92%)	**$49,600 (118%)**	$48,200 (112%)	$48,800 (109%)	$46,700 (116%)	$49,300
51-4111	Tool and Die Makers	$62,500 (129%)	**$68,800 (163%)**	$61,200 (142%)	$64,600 (144%)	$67,600 (167%)	$68,300
51-9161	Computer Numerically Controlled Tool Operators	$45,000 (93%)	$45,800 109%	$47,800 111%	**$49,000 109%**	$46,700 116%	$48,500
51-9162	Computer Numerically Controlled Tool Programmers	$58,400 (121%)	$59,600 141%	**$65,200 151%**	$57,500 128%	$59,900 148%	$60,800
17-3028	Calibration Technologists and Technicians	$55,400 (114%)	$58,600 139%	$62,100 144%	**$66,600 149%**	$59,500 147%	$61,300
11-3051	Industrial Production Managers	**$131,200 (271%)**	$121,700 288%	$117,100 271%	$115,700 258%	$109,000 270%	$125,600
MIT Living Wage—1 adult, no children		$48,448	$42,187	$43,196	$44,848	$40,359	--

Note: A dark cell represents the state with the highest wage for a Standard Occupational Classification (SOC) occupation. Parenthetical percentages represent the incumbent occupation wages relative to living wages, based on the Massachusetts Institute of Technology (MIT) Living Wage Calculator.

Sources: BLS 2023c; Glasmeier and MIT 2024.



Policies to help develop a skilled BEV manufacturing workforce

This section presents five key recommendations to develop a skilled BEV manufacturing workforce. The recommendations speak to both the need for upskilling and reskilling workers currently engaged in manufacturing ICEV-specific power train components and for developing the new workforce to meet the emerging opportunities in BEV manufacturing.

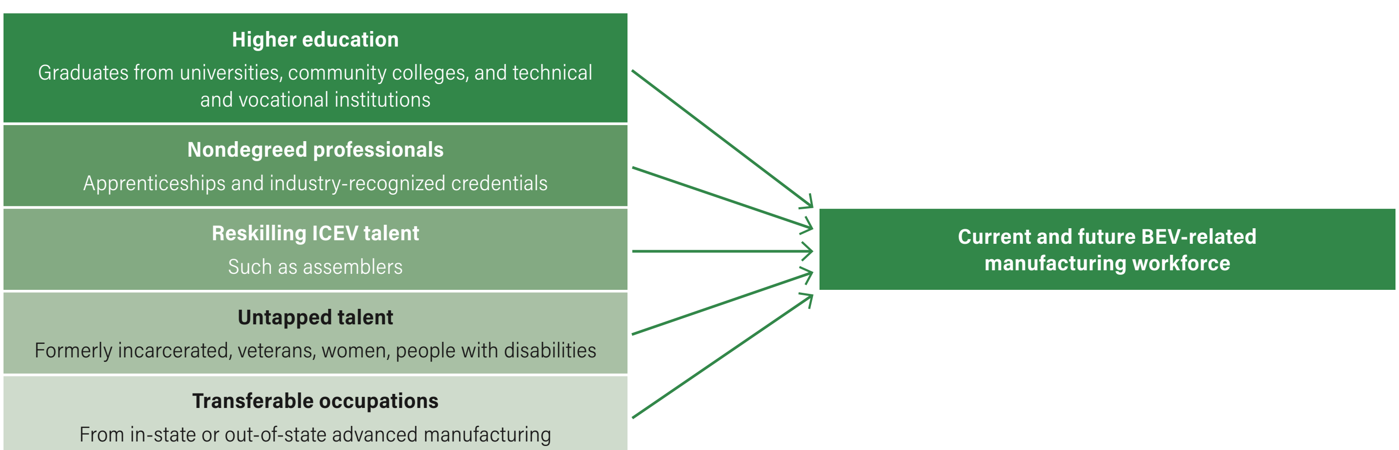
The US BEV industry will benefit from a well-trained automotive manufacturing workforce, with the shift toward BEVs requiring both training and retraining the workforce to manufacture and assemble the power trains and vehicles of the future. Specifically, this can be done in a way that preserves job quality and supports equity and diversity in the workforce. Transition policies should support retraining and placing dislocated workers in comparable quality jobs along the BEV supply chain and adjacent industries.

As various stakeholders in the BEV industry attempt to address worker transition and impact from the shift to BEVs, it bears keeping in mind that the history of worker transition and training programs in the United States, both overall and in the context of the energy transition, has been fraught with challenges. Several analyses have highlighted that the United States has, for decades, performed poorly at training and transitioning manufacturing workers impacted by trade (D'Amico and Schochet 2012; Oeschger 2022). The energy transition has led to job displacement and worker insecurity in energy-intensive industries, especially in fossil fuel extraction. These workers, who tend to be older and often employed in high-wage positions in their former industry, have faced large earning losses and challenges finding new employment (Colmer et al. 2024; Parks and Baran 2024). Studies have also raised concerns about the effectiveness of public sector training programs, with limited or no impact on employment or wages for participants; funding shortages, which have limited the reach and potential impact of programs; excessive bureaucracy and restrictive rules; the lack of alignment with evolving industry needs; and the inability to keep up with rapid technological advancements (CEA 2019; Kahn et al. 2020; McConnell et al. 2016).

This section presents recommendations to develop a skilled BEV manufacturing workforce based on the research team's findings. These recommendations were developed with input from the AC, but they do not constitute its endorsement. Furthermore, the recommendations were shaped by mapping current and future sources of workers and talent (Figure 20) as well as the different stakeholders involved in the workforce and training ecosystem (Figure 21).

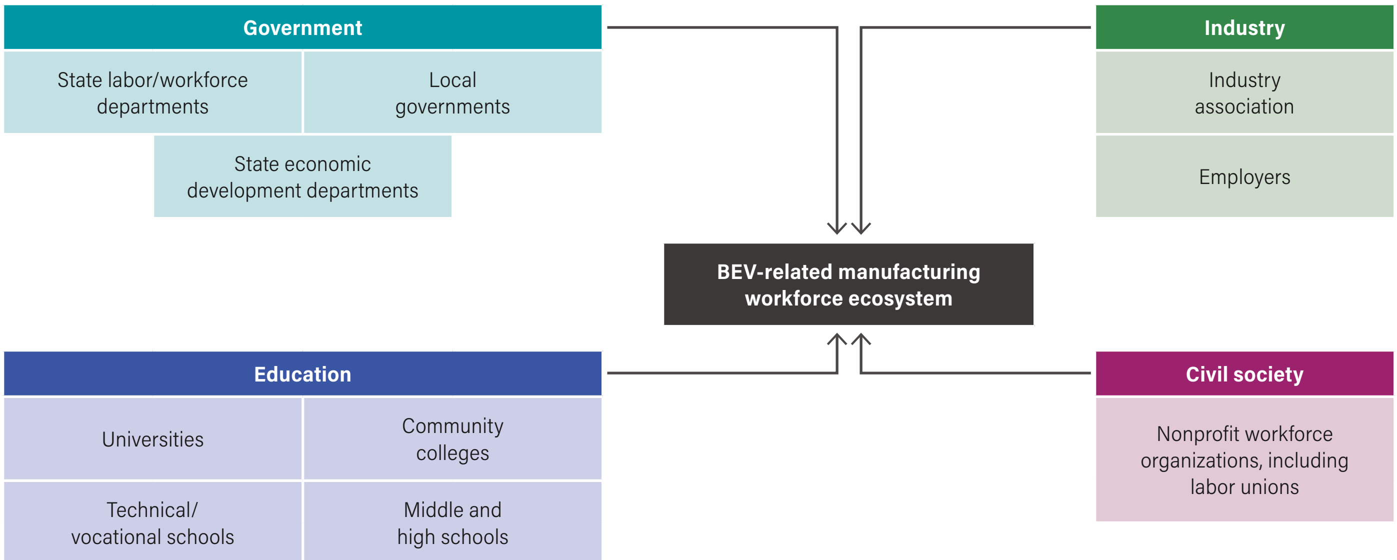
Finally, the recommendations can be adopted at the state and local levels, with state and local governments playing important roles—especially in the context of the federal government pulling back on its support—in developing accessible career pathways, fostering collaboration and partnerships among various stakeholders, and aligning policies and funding to support BEV manufacturing workforce development. The federal government is also a critical player in supporting BEV workforce development by providing funding for training programs, promoting apprenticeships, fostering partnerships and convening key stakeholders, and setting standards for careers in the BEV industry. In fact, through legislation such as the IRA and the Bipartisan Infrastructure Law, the federal government directed billions of dollars toward clean technology workforce development. With the federal government pulling back support for clean technologies through spending cuts and policy changes, the focus now shifts to leveraging nonfederal resources.

FIGURE 20 | Mapping current and future sources of talent for the BEV manufacturing industry



Notes: BEV = battery electric vehicle; ICEV = internal combustion engine vehicle.
Source: Authors.

FIGURE 21 | Stakeholders in the BEV manufacturing workforce ecosystem



Note: BEV = battery electric vehicle.
Source: Authors.

Recommendation 1: Develop proactive strategies to address job displacement and disruption of the most vulnerable occupations in automotive manufacturing

As the "Implications of the EV transition for automotive manufacturing jobs, skills, and occupations" section noted, a small subset of OEMs and Tier 1 industries will likely face significant disruption from the BEV transition. However, transition opportunities are available even for the most vulnerable occupations within this industry. These opportunities will not automatically materialize on their own, and key stakeholders will need to proactively plan for them.

Tailor transition support and policies to specific groups of workers most likely to be impacted by the transition. Policies to support the transition of automotive manufacturing workers will need to be multifaceted and address the various populations, occupational groups, and geographies that are facing different types and intensities of disruption. Targeting specific occupations within the manufacturing processes that are most likely to see employment volatility (e.g., assemblers within gasoline engine and engine parts manufacturing); regions where these facilities are concentrated; and groups of workers most at risk of displacement due to automation and skills mismatch, such as older workers, allows for policies to be customized to best meet these workers' needs and for a more direct use of resources.

Box 3 highlights examples of support for vulnerable and displaced workers. Michigan's newly created Community & Worker Economic Transition Office is providing targeted transition support to Michiganders navigating the transition in the automotive and energy sectors. In 2024, the office conducted a series of interviews and roundtable discussions with over 70 labor, industry, legislative, and community leaders in different parts of the state to obtain an understanding of how the office can support workers, communities, and employers. The feedback received includes early engagement and intervention to identify higher-risk workers and communities, improved rapid response to help workers and communities respond to negative economic events, and investment in community capacity to translate future planning goals into action (LEO 2024).

BOX 3 | Support for vulnerable automotive manufacturing workers

An equitable transition requires proactive measures to support automotive manufacturing workers who face disruptions resulting from the shift to battery electric vehicles (BEVs). Many of these measures will be subsidized by the government, but in some cases, they can be worked out in collaboration with industry partners. This support can take a variety of forms that are not mutually exclusive from each other:

- **Retraining and skills development assistance.** This can help both vulnerable and dislocated autoworkers regain employment after a job loss within the BEV industry or outside of it. Assistance can include providing wraparound services that combine job training to equip displaced workers with skills needed in high-growth industries, career counseling, and job search assistance, along with other support services that help address various barriers that individuals face when seeking retraining.
- **Transfer to other plants within the same company.** Workers can often stay employed if they agree to move to a different job in the same company, which can be in a new location. State and local policymakers, working closely with labor unions and companies, can define the conditions under which such transfers can take place, including pay protection up to a certain time in case of a transfer to a lesser-paying job and retraining assistance to enable the worker to move up professionally. In 2023, United Auto Workers (UAW) successfully negotiated to include battery manufacturing facilities within the scope of their national master agreements with Ford, General Motors (GM), and Stellantis. Workers in these battery facilities will now have the same wages, benefits, and union protections as traditional autoworkers, which is a positive outcome for workers moving from an older facility closing its doors to battery manufacturing.[a]
- **Income support.** This provides financial assistance (unemployment benefits, income supplements, and other social safety nets) to help workers cope with job losses.
- **Short-term compensation.** Auto manufacturers can temporarily halt production in some facilities as they assess demand and refine their electric vehicle strategies. Short-term compensation measures can provide impacted employees with wages and benefits during the layoff period, thereby preserving their jobs and employers' trained workforce during times of lowered economic activity.
- **Early retirement support.** This applies to older workers who are unable to find a new job but have not yet qualified for retirement benefits. It would offer those workers an earlier transition into retirement with financial benefits. In 2023, the UAW and GM negotiated a contract called the Special Attrition Program, which provides a US$50,000 benefit for retirement- and pension-eligible GM workers to voluntarily leave the company.[b]

Sources: [a] Ferris 2023; [b] Booth 2024.

Develop rapid response capabilities to address automotive facility closures. Some automotive manufacturing facilities may face closures, slowdowns, or job losses as supply chains and demand for specific components change. In February 2023, Stellantis indefinitely idled its Belvidere assembly plant in Illinois, a decision that stemmed from various reasons, including declining sales for the Jeep Cherokee and high electrification costs.[25] Around the same time, Stellantis announced millions of dollars in investment in EV facilities in Indiana (Szczesny 2022; Stellantis 2023). This development impacted more than 1,000 workers in the Belvidere facility. In the short term, state and local policymakers should develop rapid response capabilities to mitigate negative transition impacts due to a facility closure and subsequent worker displacement. This can take several forms, including monitoring economic and labor market data; establishing closer coordination with businesses, unions, and economic development agencies to encourage early and confidential notification of potential layoffs; and providing immediate worker support.

Additionally, publicly available data and Worker Adjustment and Retraining Notification (WARN) Act[26] notices are often too late to help workers impacted by closures and layoffs. Therefore, timely and proactive action to address potential disruptions requires close communication between state and local government officials and employers. Businesses can often be tight-lipped about impending closures, making it difficult for states to plan ahead and implement effective economic development at scale. However, states can undertake a range of economic forecasting and monitor economic and labor market data to better prepare for or respond to facility closures.

Emphasize collaboration and coordination among state and local economic development and workforce development agencies. Collaborative efforts can include colocating agency staff, sharing data, establishing joint workforce training programs with employers, using multiple funding streams to support a single workforce development program, and working together to attract other types of manufacturing to a region. These two systems often work with one another because their missions are fundamentally linked, but explicit focus on the automotive manufacturing industry can help focus and more clearly crystallize these collaboration efforts. In Michigan, the Michigan Department of Labor and Economic Opportunity (LEO) and the Michigan Economic Development Corporation have been collaborating to train workers for the EV-related manufacturing industry through initiatives such as the EV Jobs Academy (Gagnon Rodriguez and Trousdale 2024; LEO n.d.).[27] This ensures a coordinated approach between the two agencies in their efforts to align training programs with industry needs.

Beyond alignment on business recruitment and skills development, economic development and workforce development agencies can also collaborate on data-sharing by creating, for instance, a data-sharing platform to include information on workforce, demographic, land, economic development, and more. Businesses could then view all of the pertinent information about a state on this platform rather than having to contact multiple state departments.

Prioritize the development of local economic and workforce development initiatives to support new industries in regions that are most prone to acute plant closures (such as engine component manufacturers). This includes identifying local strengths, targeting specific industries, and ensuring a skilled workforce is ready for emerging opportunities. Battery manufacturing has become an integral part of BEV production, and states are capitalizing on this opportunity by attracting battery manufacturing facilities and developing the necessary supply chain, including producing the raw materials for batteries and recycling used batteries. In addition, states can strategically invest in broader transportation and advanced manufacturing industries, such as aerospace, robotics, automation, advanced materials, and semiconductors, which significantly overlap with the skills, technologies, and supply chain needs of BEV manufacturing. This type of diversification strategy can support a wide range of manufacturing jobs, create transition opportunities (with some reskilling) between industries, and build a more resilient economy. Michigan is investing significantly in Hemlock Semiconductor, a polysilicon manufacturer whose product is used in both semiconductors and solar panels. This investment helps link the state to the broader technology and clean energy economy. Similarly, the Accelerating Ohio's Auto & Advanced Mobility Workforce Strategy is built on attracting a broader automotive, aviation, aerospace, and advanced mobility industries to Ohio.

Focus on midcareer training programs and upskilling programs that help existing workers address gaps in their knowledge and skills for new technologies associated with BEVs or more automated manufacturing processes. These programs, particularly for dislocated or at-risk workers, focus on equipping individuals to learn new skills, improve existing ones, and adapt to changes in the workplace. OEMs are increasingly investing in training and upskilling programs to address their specific workforce needs. GM launched a training program through the GM Automotive Manufacturing Electric College to help prepare its employees for the EV push. The program provides a full salary during the training period, which lasts 6–12 months at GM's Global Technical Center in Warren, Michigan, before transitioning into one of GM's assembly facilities. Likewise, BMW opened a training center at the site of its Spartanburg, South Carolina, manufacturing facility to enhance its employees' digital skills to meet the rapid pace of the automotive industry's digital and electric transition.

However, many small and medium-sized auto manufacturing businesses can face challenges in providing upskilling programs due to limited resources and time constraints. State and local governments can play a role in funding and supporting midcareer training and upskilling programs for such employers. Many states already have programs to close the skills gap among workers and equip them with new skills and certifications in high-demand industries; examples include Texas's Skills Development Fund, Ohio's JobsOhio Workforce Grant, and Arkansas's ReSkill Arkansas. States with significant automotive manufacturing presence can leverage their existing programs to focus on reskilling their workforce for the BEV industry, including assisting smaller companies in the BEV space with their workforce needs.

Recommendation 2: Train workers for new digital, advanced manufacturing, and specialized skills

To effectively train workers for the demands of the BEV manufacturing industry, the focus needs to be on digital literacy, advanced manufacturing skills, and specialized BEV skills. This includes upskilling existing automotive workers and attracting new workers with a growth mindset, especially in battery technology, electrical systems, and software engineering. Community colleges, in particular, are especially crucial for training workers because their agile, community-focused approach allows them to quickly adapt curriculum to meet the evolving needs of the BEV industry.

Tailor training programs to focus on core math, basic mechanical systems, data literacy, and systems thinking coursework. The increased use of technologies such as robotics and AI is altering the kinds of skills that workers involved in BEV manufacturing require, and the pace of change is only expected to increase. Training programs need to adapt to these changes and offer compelling workforce programs that attract prospective students and retrain existing automotive workers to new jobs within the industry. For instance, the increasing digitization and automation of BEV manufacturing processes can generate vast amounts of data across the production process. Manufacturing workers must be able to analyze this data effectively to be able to troubleshoot problems, optimize production efficiency, and drive continuous improvements. State agencies, educational institutions, and training providers should work with employers or industry associations to identify specific remedial curriculum and data literacy geared toward automated manufacturing processes and systems diagnostics. Funding can be targeted toward short-term credentials and industry-focused programs that integrate these necessary skills.

Develop shared industry resources to strengthen upskilling and training offerings. This approach can save costs, improve quality of training, and provide greater access to relevant skills development opportunities for individuals within the BEV industry or even a group of related industries (BEVs share many common elements with other technologies, such as batteries for stationary storage and power electronics for rooftop solar). Although the current space is intensely competitive due to emerging technologies and proprietary manufacturing processes, there may still be opportunities for

shared infrastructure. For example, many community colleges lack the funding for replica manufacturing machinery or equipment, which can limit their ability to provide relevant training for the manufacturing workforce. However, a shared training center with mock production lines, machining workshops, and quality control stations can be useful for a range of manufacturing firms, including the BEV industry. The Marshall Advanced Manufacturing Center at Marshall University in West Virginia offers one such example. For an hourly fee, manufacturers and other entities can access the center's advanced manufacturing equipment, including 3D printing, which is used across automotive, medical, aerospace, and other industries (MAMC n.d.). In addition to sharing equipment, experienced faculty could also be rotated between institutions to ensure that they are providing training statewide.

Create a standardized training curriculum that can be used to support training providers to develop new training programs in geographies with burgeoning BEV manufacturing. With recent changes in the federal government's strategy toward BEVs, a coalition of employers, industry associations, educational institutions, and states will need to collaboratively lead standardized curriculum development, at least over the next few years. The Biden administration had launched initiatives to develop standardized training programs for BEV manufacturing skills. For instance, the DOE created national guideline standards for registered apprenticeships for battery machine operators—individuals who operate and maintain various machinery used in the manufacturing of batteries ranging from machines that assemble battery components to those that test and package finished batteries—under the Battery Workforce Initiative (DOE n.d.). The new standards provide a detailed list of the skill requirements and competencies for workers in advanced battery manufacturing facilities and are meant to inform the development of a comprehensive curriculum and training materials for companies and training providers. Similar national standards can be created for other in-demand occupations within other parts of the battery supply chain (e.g., battery repair, battery materials processing, and recycling) and the rest of BEV manufacturing (e.g., electromechanical and mechatronics technologists and technicians). Such standards, which encourage a core curriculum while allowing for local specialization in response to evolving industry needs, can ensure that graduates are equipped with a consistent set of sought-after skills.

Recommendation 3: Reduce risk and uncertainty for BEV manufacturers

The United States is still at an early maturity phase with regard to BEV adoption. BEV adoption will be slower without government incentives and mandated emissions standards. Industry requires certainty and stability when making decisions about future investments. With the federal government backsliding, it is even more crucial for US states to strengthen their policies to support the transition to BEVs, including by building robust charging infrastructure, providing incentives and rebates, and setting targets and mandates. This can help sustain a positive outlook for the BEV industry in the United States.

Continue to send strong market signals to industry and support consumer adoption where possible. To do this, state and local governments will need to prioritize policies and actions that incentivize BEV ownership and address consumer concerns. These market signals can include continuing to build out charging infrastructure through state tax incentives, reformed local zoning laws, and proactive coordination with electric utilities; highlighting BEV success stories; or offering state subsidies tied to job quality for operations and manufacturing employment. Even automotive manufacturing states, many of which continue to lag in BEV adoption, need to enact policies that can encourage consumers to buy BEVs. In addition to the emissions reduction and health benefits of switching to BEVs, a higher rate of BEV adoption also brings economic and employment benefits; consumers save money by owning a BEV versus a gasoline-powered vehicle, and they can then spend this money to buy local goods and services (Saha et al. 2023). Support for consumer adoption of BEVs will be important to attract workers into BEV manufacturing. If new workers get the impression that the industry is too volatile, there may not be enough workers going into the industry. Highlighting that BEV production has already brought thousands of manufacturing jobs back to America can also help build bipartisan support.

Consider offering state- or local-level conversion grants or loan guarantees to upgrade and retain existing manufacturing locations. These grants can follow the form of the federally sponsored and DOE-led Domestic Automotive Manufacturing Conversion Grant program, which provided funding to convert facilities to EV manufacturing. In addition, US states have been offering various loan guarantees and grants to support the conversion, upgrade, or retention of existing manufacturing facilities. These programs can be tailored to specific industries, such as the automotive. They can be geared to support smaller manufacturers and facilities that may otherwise struggle to secure funding, and they can focus on facilities that have recently stopped operating or will soon cease operations.

Proactively monitor and support the BEV industry to address external volatilities in the industry. The BEV landscape is rapidly changing, and OEMs, suppliers, consumers, and policymakers are sending—and receiving—a mixture of signals that range from an accelerated ramp up of BEV adoption to a decades-long period of transition. This means that policymakers at the state and local levels cannot simply enact legislation and adopt policies and assume the status quo will persist. Rather, the EV industry requires active monitoring of the situation, tracking of industry metrics, and frequent communication with employers through economic and workforce development staff to proactively address challenges or obstacles to attracting, retaining, or onboarding new workers. Attentiveness and proactive interventions can help ensure that policy meets the moment rather sooner.

Recommendation 4: Invest in workforce development and training programs tailored to specific needs within a state

BEV manufacturing investments are spreading beyond the traditional automotive manufacturing hubs of Michigan and Indiana to states such as Georgia and Nevada, which do not have an established automotive manufacturing base. The talent ecosystem—comprising middle and high schools, technical and community colleges, universities, industry associations, state and regional economic development organizations, nonprofit workforce organizations, and employers—will need to adopt different strategies for workforce development and training programs.

Assess state-specific workforce needs, and tailor training programs to meet those needs. “Legacy” automotive manufacturing states will need different training curriculum support than those that are largely developing an automotive manufacturing ecosystem from scratch. Legacy states will have an experienced but aging workforce with deep knowledge of ICEVs. They will need to focus on upskilling their automotive manufacturing workforce for new BEV technology, robotics, and software integration. Updating apprenticeship programs to cover electrical, electronic, and software skills can be one of the strategies for curriculum development. Legacy states should also focus on partnering with community colleges and universities with established automotive manufacturing programs to integrate BEV modules. Legacy states may also need to develop curriculum that supports both the ICEV and BEV industries to enable a phased transition. New BEV manufacturing hubs will need to build an entirely new talent pipeline with little prior automotive experience. New states will need to collaborate with education and training partners to create a BEV-specific curriculum from the ground up, with emphasis on developing foundational knowledge covering automation, robotics, and the basics of EV and battery production. Creating a new, highly skilled workforce can be a challenge in states with less manufacturing history, making it important for such states to market their programs to new workers with backgrounds in chemistry, electronics, and software engineering.

Prioritize supporting the expansion of, and access to, established training programs with a proven record of success before creating entirely new programs. Most regions with community colleges or strong union halls already have baseline versions of automotive manufacturing training programs that have the potential to expand into BEV manufacturing training programs. Adding BEV-specific curriculum can minimize the amount of program restructuring needed. One analysis by the National Association of State Energy Officials; the American Association of State Highway and Transportation Officials; and Duke University's Nicholas Institute for Energy, Environment & Sustainability has identified 17 colleges and universities offering training programs related to EV manufacturing across 10 southeastern states, including the BlueOval SK Battery Manufacturing Training Program at Elizabethtown Community and Technical College in Kentucky and the Electric Vehicle Professional Technical Certificate of Credit program at Savannah Technical College in Georgia (Gowdy 2024). This analysis also identified existing automotive manufacturing programs that can be expanded to offer BEV-specific curriculum. Information like this can be a starting point for state and local officials in BEV manufacturing states to take stock of what is already there, what is working, and how successful programs can be scaled.

This can also help address stakeholder concerns about confusion or lack of awareness about existing initiatives and whom they are meant to serve. Some of these programs appear duplicative, indicating that scarce resources are not being deployed effectively. Documenting the various automotive manufacturing initiatives being led by training partners in each state, creating a greater understanding of the unique roles and responsibilities of stakeholders in the talent ecosystem, and increasing access to proven programs can all facilitate collaboration and alignment in the ecosystem. Industry associations—such as the Motor & Equipment Manufacturers Association (MEMA)—training providers or state and local governments can be useful convenors that help mitigate concerns about intellectual property and potential conflicts of interest between private firms.

Recommendation 5: Improve job quality and ensure equitable access to opportunity for all

Workers in automotive manufacturing want good paying, high-quality jobs in safe work environments, irrespective of the energy source that powers the final product. As presented in the "Implications of the EV transition for automotive manufacturing jobs, skills, and occupations" section, the automotive manufacturing workforce displays some notable demographic trends. Black workers are represented at a higher rate compared to the overall labor force, and workers without a four-year degree account for a significant share of workers. Thus, the US automotive manufacturing industry is important not only for a region's economic development but also for advancing racial and educational equity. Women are underrepresented in the automotive manufacturing workforce, so the BEV transition presents an opportunity for underrepresented and historically marginalized groups to take advantage of the economic gains the transition can bring.

Support preapprenticeships, apprenticeships, and on-the-job training for workers as crucial mechanisms to support job quality. These programs provide a combination of practical experience and classroom instruction and can provide broader access to skilled careers. Apprenticeship programs have shown positive outcomes for both apprentices and employers. Apprentices benefit from increased earnings, improved career advancements, and higher job satisfaction, and employers benefit from a diverse workforce, employee loyalty, and lower employee turnover (GAO 2025; Gardiner

2023).[28] Strong apprenticeship and on-the-job training programs that emphasize training in cutting-edge machine operation, automation, and AI technologies can bolster job quality outcomes among job seekers while also supporting the automotive industry as it updates its manufacturing lines to expand into BEV production. Furthermore, it can be challenging and expensive for training providers to stay current with evolving technologies within BEV manufacturing. That is one reason why apprenticeships and work-based learning opportunities can be effectively deployed to address this barrier.

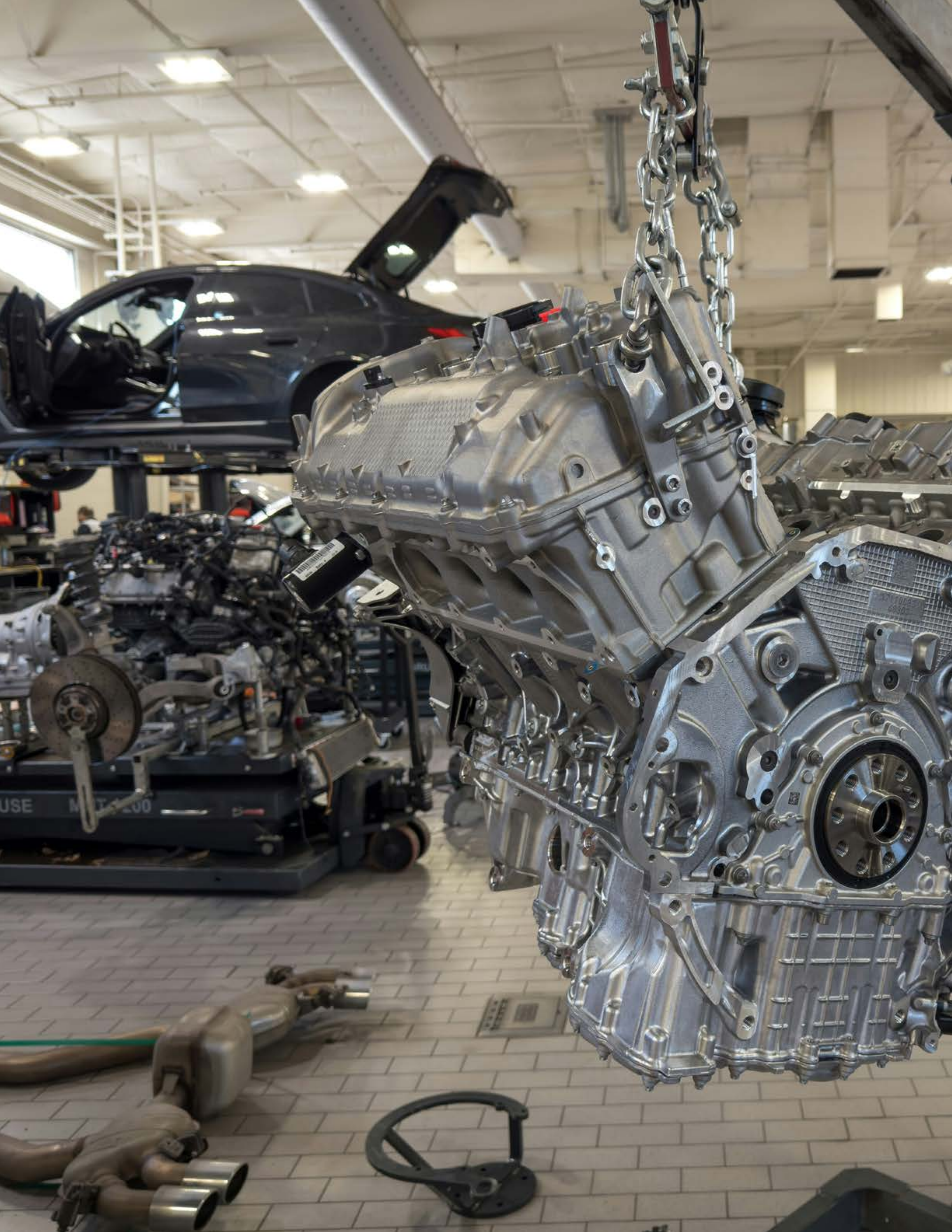
States can consider offering tax credits to companies that hire employees from registered apprenticeship programs, which can increase the demand for these programs and help expand training opportunities. States can offer funding support and incentives to postsecondary institutions that provide classroom instruction for apprenticeships, as well as to middle and high schools that promote youth apprenticeships. Public support of these programs could also be contingent upon postgraduation job quality standards. Rivian, for instance, launched an apprenticeship program in 2023 to train staff for its future manufacturing plant in Georgia. Participants will attend Georgia community colleges for the first 6 months before completing another 12–18 months of on-the-job training at Rivian's existing plant in Illinois. Tuition will be covered by Georgia's Helping Outstanding Pupils Educationally career grant program, and participants will be paid as maintenance technicians by Rivian while in the program.

Build awareness of careers and opportunities in the BEV industry, prioritizing awareness of high-demand BEV occupations. Career awareness continues to be a significant challenge for the automotive industry. Leaders in the skilled trades and manufacturing industry identified a lack of career awareness, particularly careers that do not require a college degree, as one of the driving forces behind the shortages of key roles, such as electricians and mechanics. Addressing the lack of career awareness will strengthen workforce pipelines and reframe existing misconceptions about noncollege careers. Efforts to address this challenge can include organizing workshops where students can interact with BEVs, connecting students with companies in the BEV industry for internship opportunities, encouraging schools to offer courses related to BEV technology, sharing predeveloped materials with middle and high schools and getting regional career one-stop locations to promote awareness about the breadth of BEV jobs among job seekers. Career awareness programs can also demonstrate how the automotive manufacturing industry and its careers have changed over the past 50 years.

Create partnerships to engage groups that may have unique barriers to entering or reentering the workforce. Automotive manufacturers must move beyond traditional talent approaches and innovate to improve their talent recruitment strategies and make automotive manufacturing opportunities as attractive as possible to a wide range of job seekers (women, formerly incarcerated individuals, veterans, and people with disabilities). Partnering organizations, such as the Manufacturing Institute's Heroes MAKE America, Women in Manufacturing, and the Society of Women Engineers, can help automotive manufacturers connect with a diverse group of people who have historically not participated in the industry. The Manufacturers Alliance, a leading industry organization representing manufacturers across the United States since 1933, outlined a three-phase diversity and inclusion program for manufacturers (Manufacturers Alliance

2016). The three phases of these best practices are to implement fundamentals (e.g., track and report workplace diversity metrics; work with diverse external partners), establish expectations (e.g., train managers and executives on diversity and inclusion), and drive accountability (e.g., reward diversity and inclusion achievements; publish progress publicly). Sharing these practices with employers and supporting their deployment can help a region increase access to opportunities for all residents.

Explore tiered incentives for manufacturers based on job quality standards. For example, offering certain incentives or tax breaks for a workforce that receives pay commensurate with local living standards or a region's median wages would present a straightforward path to supporting better job quality outcomes. It is also important to ensure that tracking and proving eligibility for these incentives is not too burdensome; smaller manufacturers may not have adequate staff resources for more comprehensive tracking requirements. Going further, states can signal support for community benefits agreements (CBAs) (or codify them into legislation) that enable employers and local communities to enter into agreements to provide benefits such as local hiring and creating high-quality jobs. New Flyer, an electric bus manufacturer, entered a CBA with Jobs to Move America and Greater Birmingham Ministries in 2022 that established several workforce benefits. These include the provision that 45 percent of new hires and 20 percent of promotions in the company's Anniston, Alabama, facility would be recruited from groups that have been historically disadvantaged; developing a preapprenticeship program to train new workers, with preferential entry for disadvantaged groups; establishing an anonymous reporting system for harassment and discrimination; and conducting semi-annual workplace safety training sessions. Since the agreement was negotiated, New Flyer has successfully increased its hiring and promotion of workers from historically disadvantaged groups in its Anniston facility (Saha 2024).



Conclusion

Despite an uncertain political and business environment in 2025, the future of US passenger cars is fully electric. However, the transition to a successful BEV future will stall without a skilled BEV manufacturing workforce pipeline. The transition will require robust workforce and training programs to support its growth because the differences between ICEVs and BEVs will impact automotive manufacturing processes. Whereas some occupations and roles related to ICEV manufacturing will see declining demand, new skill sets in growing parts of BEV manufacturing will be highly sought-after. All these shifts will require upskilling and reskilling existing workers and training new entrants into BEV manufacturing.

Investments to scale up EV manufacturing in the United States have increased significantly in various states over the past few years, with manufacturers announcing roughly $200 billion in investments for US EV and EV battery manufacturing facilities as of September 2024 (EDF 2024; Taylor et al. 2025). Along with the transition to manufacturing BEVs, the US auto industry is also undergoing broader changes, including structural shifts in supply chains and the growing integration of automation in vehicle manufacturing processes. Although recent actions proposed by the federal government have raised uncertainty, automakers are keen to protect their BEV investments and serve a growing consumer base domestically and globally. Policymakers are also keen to ensure that the BEV industry can spur economic development, generate meaningful employment opportunities, and maintain industrial competitiveness.

At the heart of the BEV transition and this dynamic industry are workers who build various vehicle components and assemble them into final products. The US auto industry currently employs close to 900,000 workers just within OEMs and Tier 1 industries. As the US BEV manufacturing industry grows, there is an essential need to understand how scaling up BEV manufacturing will impact workers across the industry due to shifting skill requirements and concerns related to job quality and wages as well as to identify strategies that can help ensure no workers are left behind.

Based on a survey of automotive manufacturing firms, stakeholder interviews, and a literature review accompanied by insights from relevant secondary data sets, this report has identified the types of automotive manufacturing occupations that are likely to face disruption and the types of BEV manufacturing occupations and skills that will be in demand. It also discussed other important workforce considerations, such as the geographic implications of existing BEV industry trends, job quality concerns, and workforce training needs.

This analysis reveals that a small subset of workers within OEMs and Tier 1 industries (ICEV-specific industries such as engine and engine parts manufacturing) will likely face significant disruption from the BEV transition. But even for the most vulnerable occupations within this subset, there are transition opportunities via upskilling and reskilling for emerging roles in EV and battery production as well as adjacent advanced manufacturing industries. The BEV transition will also increasingly require new digital, advanced manufacturing, and BEV-specific skill sets. BEV-specific knowledge related to high-voltage safety and battery manufacturing processes are two key categories of skilling needs. Additionally, employers will likely need to emphasize skills for managing increasingly automated manufacturing processes, which are often introduced while factories upgrade or adjust production lines and processes for BEV manufacturing.

BEV manufacturing is occurring in states where the automotive industry has historically played an important role in the local economy as well as in states that previously did not have a strong automotive manufacturing presence. This creates different education and training needs across states, necessitating tailored curriculum development for established and emerging BEV manufacturing regions. Along with the potential relocation of workers, differences across states—including wages and job quality—present additional transition challenges that will need to be addressed.

Overall, the US BEV manufacturing industry will present job opportunities to hire workers from a wide range of backgrounds as different parts of the supply chain grow in the country. However, key stakeholders will have to focus on different policies to help ensure no existing and prospective workers are left behind in the BEV transition. Based on the findings, this report outlines recommendations to address disruptions for the most vulnerable occupations and to create adequate workforce training opportunities that incorporate emerging knowledge areas and skill needs. The findings also highlight that strategies will need to ensure that available employment opportunities are widely accessible and inclusive and that the industry emphasizes job quality. Finally, developing a prosperous BEV industry that is fair to workers will require coordinated efforts from stakeholders, including businesses, government, education and training institutions, and labor unions.

Further research evaluating the experiences and perspectives of workers is also needed to better inform policies and advance the BEV transition with a people-centered approach. As highlighted by Silva et al. (2023), well-intentioned policies—for example, the implementation of retraining or relocation programs—could fail to appeal to, or even reach, workers if assumptions are made about their beliefs, needs, and behaviors without their direct input. Hence, drawing lessons from stakeholders such as current and former autoworkers, company managers, and community members is an important area of further research that can reveal meaningful insights about the needs of differently situated groups and how they perceive the risks and opportunities that BEVs present.

Appendices

Appendix A: Exploded parts list sources

The research team reviewed a range of resources to create the exploded parts list shown in Table 2. This exploded parts list provides a breakdown of key automobile components that are assembled to produce finished automobiles. The research team used the exploded parts list to better understand key differences between ICEVs and EVs and identify which parts of the vehicle manufacturing supply chain could face disruptions.

Resources include industry "teardown" sheets, news articles, a previous World Resources Institute (WRI) analysis that compares differences in ICEV and EV components, research team analysis of various ICEV and EV parts catalogs, and an interview with an automotive professional in the vehicle maintenance and repair industry (Brooke 2022; Chatelain et al. 2018; Motortrend 2018; Tesla n.d.a; Toyota n.d.; Wang et al. 2024). See references for full citations.

Appendix B: Survey methodology, questions, and toplines

The research team conducted online employer surveys with automotive manufacturing firms in the United States. The survey was programmed, tested, and distributed to prospective respondents by BW Research. Respondents were recruited through employer email samples and third-party email online panels. To qualify for the survey, respondents were required to be knowledgeable about hiring or staffing practices at their firm.

The survey was fielded between May 23 and August 12, 2024. In total, 330 firms participated in the employer survey. The average length for the survey was 13 minutes. The maximum overall margin of error is ±5.38 percent at a 95 percent confidence interval.

Table B-1 provides an overview of the survey methodology used for the project. Table B-2 compares the survey universe with survey respondents by firm size.

The survey was also distributed to external third-party networks (via AC members) to maximize the number of responses, which introduces some selection bias; however, including more large employers also provides valuable insight into the perspectives and priorities of larger manufacturing facilities.

TABLE B-1 | Overview of survey methodology

METHOD	ONLINE SURVEY (EMAIL AND PANEL RESPONDENTS)
Universe	52,323 establishments in the United States across original equipment manufacturers, Tier 1, Tier 2, and Tier 3 suppliers.
Number of respondents	330 total completes by firms in the United States
Average length	Online survey: 12.9 minutes
Field dates	May 23–August 12, 2024
Margin of error	The maximum overall margin of error for questions answered by all 330 respondents is ±5.38 percent (95 percent level of confidence)

Source: Authors.

TABLE B-2 | Comparison of survey universe and survey respondents by firm size

NUMBER OF EMPLOYEES	SURVEY UNIVERSE (%)	SURVEY RESPONDENTS (%)
Less than 50	83	6
50–99	6	11
100–250	6	19
250+	5	64

Source: Authors.

Survey toplines

Introduction

BW Research is working with WRI to explore the workforce changes as BEVs gain market share in the passenger vehicle market. This survey aims to engage with manufacturers throughout the EV market, including battery materials and pack manufacturers; OEMs; charger manufacturers; and Tier 1, Tier 2, and Tier 3 manufacturers.

Please complete this survey and provide your email address to be entered into a raffle to win one of four runner-up $250 Visa gift cards and one grand prize $1,000 Visa gift card.

[IF NEEDED]: This survey has been commissioned by WRI, a global research nonprofit organization.

[IF NEEDED]: The survey is being conducted by BW Research, an independent research organization, and should take approximately 15 minutes of your time.

[IF NEEDED]: Your individual responses will **not** be published; only aggregate information will be used in the reporting of the survey results.

Screener questions

A. Is your firm involved with the manufacturing of finished or component goods for light-duty BEVs, EV battery packs or materials, or EV charging stations? (n=330)

100.0%	Yes
0.0%	No
0.0%	Don't know/refused

B. Please enter the zip code of your primary location. (If you have more than one location, please provide the zip code of the location to which you report. The remainder of this survey will focus on the single location where you report.) (n=330)

Percent	Census region	Percent	Census division
36.1	South	21.5	East North Central
25.2	Midwest	18.2	South Atlantic
20.0	Northeast	17.6	Middle Atlantic
18.8	West	14.2	Pacific
		9.7	East South Central
		8.2	West South Central
		4.5	Mountain
		3.6	West North Central
		2.4	New England

C. Are you able to speak about the management and hiring decisions at your organization? (n=330)

100.0%	Yes
0.0%	No
0.0%	Don't know/refused

[IF SC = “No”, SKIP TO Q22 THEN END]

D. Which sector is your business **most directly** involved with? [RANDOMIZE] (n=330)

100.0%	Manufacturing or design
0.0%	Wholesale distribution
0.0%	Retail trade
0.0%	Sales
0.0%	Maintenance or repair
0.0%	Professional or business services
0.0%	Other

E. Which product lines are your business involved with? [SELECT ALL THAT APPLY]—*Multiple responses permitted; percentages may sum to more than 100 percent.* (n=330)

43.3%	Component parts for EVs (i.e., motors, transmissions)
43.0%	Assembly of EVs
37.0%	Battery pack components
36.1%	Finished battery packs for EVs
33.0%	Subcomponent parts for EVs (i.e., rotor, gear sets)
31.5%	Battery pack materials and subcomponents
28.2%	Component parts for ICEVs (i.e., engines, transmissions)
25.2%	Subcomponent parts for ICEVs (i.e., pistons, differential, gear sets)
25.2%	Assembly of hybrid vehicles
22.1%	Component parts for hybrids (i.e., engines, transmissions)
22.1%	Component parts for charging stations
22.1%	Subcomponent parts for charging stations
21.8%	Finished charging stations
21.5%	Assembly of ICEVs
20.9%	Battery pack recycling or reuse
20.0%	Subcomponent parts for hybrids (i.e., pistons, differential, gear sets)
1.5%	Other

[IF SE = "Finished charging stations", "Component parts for charging stations", OR "Subcomponent parts for charging stations", ASK SF, OTHERWISE SKIP]

F. Which types of charging stations do you design or manufacture parts or finished products for? [SELECT ALL THAT APPLY]—*Multiple responses permitted; percentages may sum to more than 100 percent.* (n=330)

65.7%	Level 1 chargers (120V)
93.3%	Level 2 chargers (208V or 240V)
75.4%	DC fast chargers (Level 3)
0.0%	Other
0.0%	Don't know/refused

G. In your own words, please tell us what your company designs or manufactures? (n=330)

42.1%	Automobile component parts
25.2%	Battery packs and components
18.5%	Automobile manufacturing
6.4%	Charging stations and components
7.9%	Other

Section 1: Employment

1. Including all full-time and part-time employees, how many **permanent** employees work at your current location? Please include any employees working remotely who report out of this location. [DO NOT ACCEPT 0 AS A RESPONSE] (n=330)

Average	Median
499.0	350.0

5.8%	Less than 50 employees
11.2%	50–99 employees
12.1%	100–49 employees
3.6%	150–99 employees
3.0%	200–49 employees
64.2%	250 employees and over

[IF SE = "Assembly of EVs", "Component parts for EVs", "Subcomponent parts for EVs", OR "Battery pack recycling or reuse", ASK Q2, OTHERWISE SKIP]

2. Of all permanent employees working at your current location, how many are directly involved with BEVs or their components? (n=251)

Average	Median
46.0% of employees	42.0% of employees

22.7%	Less than 25% of employees
31.1%	25%–49% of employees
27.9%	50%–74% of employees
10.4%	75%–99% of employees
7.2%	100% of employees
0.8%	Don't know/refused

[IF SE = “Assembly of EVs”, “Component parts for EVs”, “Subcomponent parts for EVs”, OR “Battery pack recycling or reuse”, ASK Q3, OTHERWISE SKIP]

3. Of all permanent employees working at your current location, how many are directly involved with traditional ICEVs or their components? (n=251)

Average	Median
29.3% of employees	23.0% of employees

52.2%	Less than 25% of employees
27.9%	25%–49% of employees
13.5%	50%–74% of employees
3.6%	75%–99% of employees
2.8%	100% of employees
0.0%	Don't know/refused

4. Of your (**INSERT Q1#**) workers**,** how many are represented by a union or covered under a collective bargaining agreement or project labor agreement? (n=330)

16.4%	1%–25% of employees
13.3%	26%–50% of employees
13.9%	51%–75% of employees
27.0%	76%–100% of employees
28.2%	None (0% of employees)
1.2%	Don't know/refused

5. If you currently have (**INSERT Q1#**) workers, at your location, how many employees **did you have 12 months ago**? (n=330)

69.1%	Fewer employees
16.4%	Same number of employees
14.5%	More employees

6. If you currently have (**INSERT Q1#**) workers at your location, how many employees do you expect to have at your location **three years from now**? (n=330)

11.2%	Fewer employees
6.1%	Same number of employees
82.7%	More employees

Section 2. Worker transitions

Next, we would like to ask you about the demand for workers as EVs grow in market share. [Ask Q7–Q9 if screener E includes ICEVs].

7. What share of your ICEV-related workforce will need to retrain or reskill to work on EVs? (n=154)

7.8%	No workers need additional training or reskilling
22.1%	1%–25% of employees
35.1%	26%–50% of employees
22.7%	51%–75% of employees
9.1%	76%–100% of employees
3.2%	Not sure/too early to tell
0.0%	Refused

8. What retraining or reskilling is necessary? (n=113)

24.8%	Knowledge or training on EVs
15.0%	Use of computer systems, AI, or robotics
11.5%	Engineering training, mechanical skills, and electrical training
11.5%	Knowledge of EV component parts and knowledge of battery packs and components
10.6%	Manufacturing processes
7.1%	Knowledge of machinery or tools
10.6%	None
2.7%	Other
6.2%	Don't know/refused

9. What occupation(s) will have the most difficult time transitioning from ICEVs to EVs? (n=117)

18.8%	Assemblers or production associates
8.5%	Mechanics or technicians
7.7%	Engineers
6.0%	Managers or supervisors
6.0%	Developers, designers, or programmers
5.1%	Maintenance workers
4.3%	Machine operators or machinists
4.3%	Laborers or electricians
3.4%	Sales, marketing, or purchasing
2.6%	Information technology or cybersecurity
0.9%	Quality control and assurance
0.9%	Logistics or warehousing
8.5%	None
9.4%	Other
13.7%	Don't know/refused

10. Do new hires to your company require additional EV-specific knowledge or skills? (n=330)

51.5%	Yes, workers will require many new additional skills or knowledge
37.6%	Yes, workers will require some additional skills or knowledge
10.0%	No, new hires generally have all the EV-specific knowledge or skills required
0.9%	Don't know/refused

[IF Q10 = "Yes, workers will require **many** new skills or knowledge" OR "Yes, workers will require **some** new skills or knowledge", ASK Q11, OTHERWISE SKIP]

11. Generally speaking, what types of new knowledge or skills are required? (n=253)

16.6%	Use of computer systems, AI, or robotics
16.2%	Manufacturing processes and safety procedures
15.4%	Mechanical skills, engineering training, and electrical training
13.0%	Knowledge or training on EVs
10.7%	Knowledge of battery packs and components
7.9%	Knowledge of EV component parts
4.7%	Knowledge of machinery or tools
8.7%	Other
6.7%	None and don't know/refused

[IF # FROM Q6 > # FROM Q1, ASK Q12, OTHERWISE SKIP]

12. What are the top five occupations your firm will hire? (n=260)

43.5%	Engineers
36.2%	Assemblers or production associates
32.3%	Managers or supervisors
26.9%	Mechanics or technicians
19.6%	Machine operators or machinists
15.8%	Logistics or warehousing
16.2%	Developers, designers, or programmers
15.4%	Quality control and assurance
12.3%	Maintenance
11.5%	Sales, marketing, or purchasing
7.7%	Information technology or cybersecurity
6.2%	Human resources
16.9%	Welders, electricians, or laborers
1.9%	None
31.5%	Other
17.3%	Don't know/refused

13. What are the top knowledge, skills, or certifications you look for among prospective new hires? (n=226)

[FORM THAT PIPES IN OCCUPATION TITLES FROM QUESTION ABOVE]

29.6%	College degree or high school diploma
27.0%	Software, programming, AI, machine learning, or robotics
26.5%	Industry-specific knowledge (parts, batteries, manufacturing processes, etc.)
23.9%	Nontechnical skills (work ethic, communication, leadership, etc.)
22.1%	Experience
12.4%	Technical or mechanical skills
11.1%	Certification (professional engineer, automotive service excellence, Occupational Safety and Health Administration, etc.)
11.1%	Machine and tool operation
8.8%	Electrical knowledge or engineering
5.8%	Technical school training
5.3%	Maintenance and repair
4.9%	None
8.0%	Other
4.4%	Don't know/refused

14. Does your company directly offer trainings or hire interns or apprentices to provide hands-on experience to prospective full-time job seekers? (n=330)

47.6%	Yes (please tell us more)
50.0%	No
2.4%	Don't know/refused

Yes (please tell us more) (n=154)

57.8%	On-the-job training
16.9%	Internships, apprenticeships, or boot camps
4.5%	Partner with outside organizations or schools
6.5%	Other
14.3%	Don't know/refused

15. Does your company partner with state agencies or local training educational institutions for workforce development? (n=330)

24.8%	Yes (please tell us more)
67.0%	No
8.2%	Don't know/refused

Yes (please tell us more) (n=60)

50.0%	Local schools, colleges, and universities
20.0%	State agencies and workforce boards
28.3%	Outside organizations and agencies
1.7%	Other

16. Where will your company look for potential new hires for assembler roles? [SELECT ALL THAT APPLY]—*Multiple responses permitted; percentages may sum to more than 100 percent.* (n=330)

78.8%	Internet job boards (Indeed, Monster, LinkedIn, etc.)
52.1%	Vocational and technical schools or technical college
37.0%	Community colleges
34.8%	Union apprenticeship programs
30.9%	Friends and family networks
19.7%	Nonunion apprenticeship programs
19.7%	Union halls
2.4%	Do not plan on hiring assembler workers
0.9%	Other

Section 3. The transition to BEVs

Next, we want to ask you about perceptions of the transition to BEVs.

17. Please tell us about the industry perspectives of the transition to BEVs. (n=330)

	Opportunity (%)	Threat (%)	Transition with some benefits and some costs (%)	Too soon to tell (%)	Don't know/ refused (%)
My suppliers generally view the transition to BEVs as a(n):	57.9	10.3	27.3	4.2	0.3
The purchasers of my products generally view the transition to BEVs as a(n):	60.3	10.6	21.2	7.6	0.3
My company generally views the transition to BEVs as a(n):	62.1	11.2	19.7	7.0	0.0
Workers at my company view the transition to BEVs as a(n):	57.3	9.1	25.2	8.5	0.0

18. In the next year, is your company expanding the manufacturing capacity at the existing location or adding new locations? [SELECT ALL THAT APPLY]—*Multiple responses permitted; percentages may sum to more than 100 percent*. (n=330)

61.2%	Yes, our company is expanding capacity of existing manufacturing locations
44.8%	Yes, our company is adding new manufacturing locations
19.4%	No, the manufacturing capacity at my location remains largely unchanged
6.4%	No, manufacturing capacity at my location is decreasing in manufacturing capacity
4.5%	We do not or will not have manufacturing capacity in the next year
1.5%	Don't know/refused

[IF Q18 = "Yes, our company is expanding capacity of existing manufacturing locations", OR "Yes, our company is adding new manufacturing locations", ASK Q19, OTHERWISE SKIP]

19. Will the new or expanded facilities incorporate new digital technologies or automation that your previous location did not have? [SELECT ALL THAT APPLY]—*Multiple responses permitted; percentages may sum to more than 100 percent*. (n=258)

75.6%	Yes, the new/expanded facility will incorporate greater automation
57.0%	Yes, the new/expanded facility will incorporate greater use of digital technologies
6.2%	No, the new/expanded facility will incorporate generally the same technologies currently deployed
1.2%	Don't know/refused

[IF Q19 = "Yes, the new/expanded facility will incorporate greater automation" OR "Yes, the new/expanded facility will incorporate greater use of digital technologies", ASK Q20, OTHERWISE SKIP.

20. What types of automation or digital systems will be used? (n=168)

38.1%	AI or robotics
23.2%	Improved machinery, equipment, software, or systems
17.9%	Automated vehicle assembly or production
6.0%	Other
14.9%	Don't know/refused

[IF Q18 = "Yes, our company is adding new manufacturing locations", ASK Q21, OTHERWISE SKIP]

21. Will the new facilities be located in a state where your company did not previously have a presence? [SELECT ALL THAT APPLY]—*Multiple responses permitted; percentages may sum to more than 100 percent.* (n=147)

13.6%	Yes, the new facilities will be in states where my company did not previously have a presence (please specify)
46.9%	No, the new facilities will be in states where my company already has at least one other existing location
36.7%	Some locations will be in new states, others will be in states with existing locations
14.3%	Too early to tell
0.0%	Don't know/refused

22. We are interested in talking with as many business managers and decision-makers as possible, in as many locations as possible. Will you please share the name and contact information of any manager involved in manufacturing automotive or EV-related products?

First and last name ____________________

Position/title Email ____________________

Phone number ____________________

Company name ____________________

Appendix C: Stakeholder interview questionnaire

Section 1. Introduction & background

Introduction and brief background on project goals and objectives: WRI and BW Research are working together to develop a better understanding of the types of manufacturing jobs that will be needed—and the types of jobs that may see a decline in demand—as a result of the transition from ICEVs to BEVs. We are conducting a range of interviews with industry professionals to develop a better understanding of the passenger vehicle manufacturing landscape and to identify potential challenges and opportunities that arise with the transition to EVs.

The information discussed in these interviews will be anonymized, and information will only be reported in aggregate.

1. Please tell us about your company and position. What is your role or vantage point in the transition to EVs?
2. How will the EV transition affect your product lines or business plan?
   i. Are new production lines being opened elsewhere or are existing production lines being transitioned?
3. At a high level, how is your company thinking about the transition to EVs when it comes to personnel?

Section 2. Key occupations

4. Are there any specific types of skills or workers that will become **less** valuable as the auto market shifts toward BEVs?
5. Are there any specific types of skills or workers that will become **more** valuable as the auto market shifts toward BEVs?
6. Is there likely to be a net increase/decline in workers in your industry?
   i. How large do you think this increase/decline will be?
7. Will workers be able to transition from one set of skills to another?
   i. Will this require any formal education or training?
      a. Do you expect that your company will provide this training, or will this be outsourced/done by external training providers?
8. Are there any differences in hours, wages, or education requirements between ICEV and BEV-related workers?
   i. Will certain roles be affected differently or have an easier/more difficult time with the transition?

Section 3. Other considerations

9. Generally speaking, do you see the transition to EVs as an opportunity or a challenge for workers?
    i. If you think both, do you think there are certain workers who will face a bigger challenge than others?
10. Are there any other folks you would recommend we speak with to better understand the impact of the transition on workers?
11. Would you be interested in serving on an advisory panel/ joining a roundtable discussion for this research project? This would entail two separate two-hour remote meetings and would give you early access to our research.

Appendix D: Additional secondary data analysis

This appendix contains an analysis of additional secondary data on the current BEV workforce collected throughout the research process. These additional secondary data provide a greater understanding of the BEV workforce, including trends in downstream Tier 2 and Tier 3 suppliers and identification of emerging growth industries that will likely play a greater role in the automotive supply chain as vehicles incorporate greater use of advanced technologies.

Tier 2 and Tier 3 suppliers

Tier 2 and Tier 3 suppliers (Table D-1) are farther down the manufacturing supply chain, and they provide subcomponents and even raw materials to the next level up the supply chain. These industries supply other industries beyond automotive manufacturers with parts and components, so the employment must be scaled down by the "Motor Vehicle Employment Prevalence" factor borrowed from MEMA industry association estimates (MEMA 2020). Motor Vehicle Employment Prevalence refers to the percentage of total employment in an industry that is related to the motor vehicle industry. It is notable that many of the most common types of Tier 2 and Tier 3 occupations (Table D-2) are also the most common occupations within OEMs and Tier 1 manufacturers (see "Implications of the BEV transition for automotive manufacturing jobs, skills, and occupations").

TABLE D-1 | Tier 2 and 3 industries

NAICS CODE	NAICS DESCRIPTION	MV EMPLOYMENT PREVALENCE[a] (%)	Q3 2023 MV EMPLOYMENT (IN THOUSANDS)	2019–2023 MV EMPLOYMENT (% CHANGE)
326199	All Other Plastics Product Manufacturing	18	54.2	1.2
326211	Tire Manufacturing (except Retreading)[b]	92	48.2	3.2
325510	Paint and Coating Manufacturing	28	12.2	-1.8
331110	Iron and Steel Mills and Ferroalloy Manufacturing	14	12.0	-0.4
327215	Glass Product Manufacturing Made of Purchased Glass	24	11.3	-3.1
324191	Petroleum Lubricating Oil and Grease Manufacturing	92	10.1	-2.5
333618	Other Engine Equipment Manufacturing	15	7.7	5.3
331315	Aluminum Sheet, Plate, and Foil Manufacturing	40	7.5	8.6
326220	Rubber and Plastic Hoses and Belting Manufacturing	32	7.5	-1.4
326212	Tire Retreading	92	6.3	3.7
332510	Hardware Manufacturing	24	5.8	-4.4
332613	Spring Manufacturing	37	5.7	-11.1
334514	Totalizing Fluid Meter and Counting Device Manufacturing	53	4.7	-8.7
335139	Electric Lamp Bulb and Other Lighting Equipment Manufacturing	28	3.4	-16.7
Total		**-**	**196.7**	**0.1**

Notes: MV = motor vehicle; NAICS = North American Industry Classification System; Q3 = third quarter; [a] MV Employment Prevalence refers to the percentage of total employment in an industry that is related to the motor vehicle industry. [b] This NAICS code also encapsulates nonmotor vehicle tire manufacturing (aircraft tires, inner tubes, etc.) and therefore does not have 100 percent employment prevalence.

Source: Authors, using BLS 2023a, 2023d.

TABLE D-2 | Top 25 Tier 2 and Tier 3 relevant occupations

SOC CODE	SOC DESCRIPTION	Q3 2023 MV EMPLOYMENT (IN THOUSANDS)	10-YEAR PROJECTED MV EMPLOYMENT (IN THOUSANDS)	10-YEAR MV EMPLOYMENT (% CHANGE)
51-2092	Team Assemblers	11.9	10.2	-14.1
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	9.8	9.5	-3.0
51-1011	First-Line Supervisors of Production and Operating Workers	9.0	8.9	-1.2
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	8.5	8.2	-3.9
51-9197	Tire Builders	8.2	7.8	-4.7
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	7.9	7.3	-7.8
49-9041	Industrial Machinery Mechanics	5.5	6.5	17.0
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	4.2	4.1	-3.8
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	3.8	3.8	-0.2
49-9071	Maintenance and Repair Workers, General	3.7	3.7	-0.4
17-2112	Industrial Engineers	3.6	3.9	8.2
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	3.4	3.1	-10.2
51-9111	Packaging and Filling Machine Operators and Tenders	3.2	3.3	2.5
51-9199	Production Workers, All Other	3.1	3.0	-1.4
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	2.6	2.7	0.2
51-4041	Machinists	2.4	2.4	-0.8
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	2.0	1.9	-2.8
51-9198	Helpers—Production Workers	2.0	1.7	-10.9
51-9161	Computer Numerically Controlled Tool Operators	1.8	1.6	-9.6
51-9011	Chemical Equipment Operators and Tenders	1.6	1.6	-2.0
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	1.6	1.6	-1.3
51-4121	Welders, Cutters, Solderers, and Brazers	1.6	1.6	-1.8
51-4023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	1.6	1.4	-13.3
17-2141	Mechanical Engineers	1.6	1.7	7.2
51-2099	Assemblers and Fabricators, All Other	1.5	1.3	-14.1
Total		106.3	102.7	-3.3

Note: The table shows occupations under three categories: Architecture and Engineering Occupations (SOC 17-0000); Installation, Maintenance, and Repair Occupations (SOC 49-0000); and Production Occupations (SOC 51-0000). MV = motor vehicle; Q3 = third quarter; SOC = Standard Occupational Classification.

Source: Authors, using BLS 2023a, 2023c.

Adjacent growth industries

The research team also identified "adjacent growth industries" that may see a greater share of employment relevant to motor vehicles as vehicles become more technologically advanced with a greater array of onboard electronics capable of self-navigation, collision avoidance, and other complex tasks (Table D-3). To identify these adjacent growth industries, the research team produced teardown analyses of common ICEVs and BEVs (Toyota Corolla, Tesla Model 3, etc.) using component lists from OEM parts catalogs and cross-referenced these against detailed NAICS descriptions (US Census Bureau 2025). Although there are no employment estimates available for these adjacent growth industries that are specific to only automotive manufacturing activity, the research team also identified the 25 most common occupations employed within these adjacent growth industries (Table D-4).

TABLE D-3 | Adjacent growth industries

NAICS	NAICS DESCRIPTION	MV EMPLOYMENT PREVALENCE (%)	Q3 2023 ECONOMY-WIDE EMPLOYMENT (IN THOUSANDS)	2019–2023 EMPLOYMENT (% CHANGE)
541512	Computer Systems Design Services	-	1,210.3	11.4
541511	Custom Computer Programming Services	-	1,179.5	15.1
513210	Software Publishers	-	653.1	37.9
518210	Data Processing, Hosting, and Related Services	-	513.0	39.6
334413	Semiconductor and Related Device Manufacturing	-	201.8	8.4
541519	Other Computer Related Services	-	145.9	16.7
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	-	137.0	0.9
334111	Electronic Computer Manufacturing	-	117.2	7.2
334419	Other Electronic Component Manufacturing	-	61.8	0.7
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	-	43.7	5.4
325180	Other Basic Inorganic Chemical Manufacturing	-	42.4	4.4
334417	Electronic Connector Manufacturing	-	22.4	-1.7
212230	Copper, Nickel, Lead, and Zinc Mining	-	18.4	0.6
335910	Battery Manufacturing	27	13.4	24.0
212290	All Other Metal Ore Mining	-	4.5	9.2
Total		**-**	**4,364.6**	**17.7**

Notes: MV = motor vehicle; NAICS = North American Industry Classification System; Q3 = third quarter.

Source: Authors using BLS 2023a, 2023d.

TABLE D-4 | Top 25 occupations within adjacent growth industries

SOC CODE	SOC DESCRIPTION	Q3 2023 EMPLOYMENT (IN THOUSANDS)	10-YEAR PROJECTED EMPLOYMENT (IN THOUSANDS)	10-YEAR EMPLOYMENT (% CHANGE)
51-2028	Electrical, Electronic, and Electromechanical Equipment Assemblers, Except Coil Winders, Tapers, and Finishers	69.2	71.3	3.1
17-2061	Computer Hardware Engineers	29.1	31.0	6.5
17-2112	Industrial Engineers	26.0	30.3	16.7
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	24.0	24.9	3.7
51-2092	Team Assemblers	20.9	19.7	-6.0
51-1011	First-Line Supervisors of Production and Operating Workers	19.5	20.8	6.2
17-2071	Electrical Engineers	18.9	20.8	9.6
51-9141	Semiconductor Processing Technicians	17.1	18.6	8.8
17-2072	Electronics Engineers, Except Computer	16.9	18.4	8.4
17-3023	Electrical and Electronic Engineering Technologists and Technicians	16.3	16.4	0.2
51-9011	Chemical Equipment Operators and Tenders	14.3	13.2	-7.7
17-2141	Mechanical Engineers	13.7	15.8	16.0
49-9071	Maintenance and Repair Workers, General	12.1	13.2	8.7
17-2199	Engineers, All Other	11.9	13.0	9.3
49-9041	Industrial Machinery Mechanics	9.8	12.3	25.9
49-2011	Computer, Automated Teller, and Office Machine Repairers	8.6	9.7	12.9
17-3026	Industrial Engineering Technologists and Technicians	8.4	9.0	7.3
49-2022	Telecommunications Equipment Installers and Repairers, Except Line Installers	7.2	8.2	13.8
51-4041	Machinists	6.1	6.4	6.5
51-9199	Production Workers, All Other	4.6	4.9	6.8
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	4.4	4.7	8.1
17-2011	Aerospace Engineers	4.4	4.8	10.2
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	4.0	4.4	9.1
51-9161	Computer Numerically Controlled Tool Operators	3.7	3.5	-3.9
51-2099	Assemblers and Fabricators, All Other	3.6	3.4	-5.4
Total		**374.8**	**398.8**	**6.4**

Notes: The table shows occupations under three categories: Architecture and Engineering Occupations (SOC 17-0000); Installation, Maintenance, and Repair Occupations (SOC 49-0000); and Production Occupations (SOC 51-0000). Q3 = third quarter; SOC = Standard Occupational Classification.

Source: Authors, using BLS 2023a, 2023c.

Abbreviations

AC	advisory council
AI	artificial intelligence
BEV	battery electric vehicle
BLS	US Bureau of Labor Statistics
BNEF	BloombergNEF
CBA	community benefits agreement
CPS	Current Population Survey
DOE	US Department of Energy
EV	electric vehicle
GDP	gross domestic product
GED	general equivalency diploma
GM	General Motors
ICEV	internal combustion engine vehicle
IEA	International Energy Agency
IRA	Inflation Reduction Act
KSA	knowledge, skills, and abilities
LEO	Michigan Department of Labor and Economic Opportunity
MEMA	Motor & Equipment Manufacturers Association
MIT	Massachusetts Institute of Technology
MV	motor vehicle
NAICS	North American Industry Classification System
NEVI	National Electric Vehicle Infrastructure
OEM	original equipment manufacturer
PHEV	plug-in hybrid electric vehicle
Q3	third quarter
RPM	revolutions per minute
RPP	regional price parity
RTW	right to work
SME	Society of Manufacturing Engineers
SOC	Standard Occupational Classification
UAW	United Auto Workers
USEER	US Energy and Employment Report
VW	Volkswagen
WARN	Worker Adjustment and Retraining Notification

Endnotes

1. The ICEV-to-BEV transition will also impact workers in other parts of the automotive industry, such as ICEV maintenance and repair workers. This report, however, focuses on automotive manufacturing workers.

2. The exact year and timeline vary by country and region, as well as the source used. For instance, China is expected to be a leader in this space, with electric vehicles outselling ICEVs as early as 2025 (Inagaki and White 2024).

3. The 30 percent job loss number is often attributed to James Hackett, former president and chief executive officer of Ford, from a forecast in 2017 (Carey 2017).

4. These are the three facilities included in the analysis: the Tesla factory in Fremont, California (previously owned by GM and Toyota); the Rivian factory in Normal, Illinois (previously owned by Mitsubishi); and the GM facility in Orion Township, Michigan (currently not operating). The analysis looked at two decades of data on the number of assembly workers at the three plants using public census data and production data from the Automotive News Research & Data Center (Weng et al. 2024).

5. The research team focused on the potential for disruption primarily on OEMs and Tier 1 industries. There are several justifications for this decision. First, the comparison of vehicle parts for ICEVs versus BEVs (Table 2) suggests that the greatest disruptions are likely to occur within a few components. Second, the impacts within Tier 2 and Tier 3 manufacturers will likely be isolated to manufacturers who produce specific subcomponents for affected components, such as inputs for exhaust systems, and there are no clearly delineated industry codes that allow the research team to consider those specific impacts. The review of secondary data and literature also expects those impacts to be small in magnitude relative to those of OEMs and Tier 1 manufacturers.

6. The research team could not extensively cover employment trends in BEV charging station manufacturing using BLS data because there are no NAICS codes that specifically depict this industry. However, the survey included BEV charging station manufacturing to provide a broader picture of the manufacturing landscape associated with BEVs (vehicle manufacturing, battery manufacturing, and charger manufacturing). Survey respondents were allowed to choose multiple products (including component and subcomponent parts for charging stations and finished charging stations) when asked about the products related to their business.

7. NAICS 336110 (Automobile and Light Duty Motor Vehicle Manufacturing) includes the OEMs that primarily assemble entire motor vehicles, including passenger cars and light-duty vehicles. NAICS 3363 (Motor Vehicle Parts Manufacturing) includes establishments that focus on manufacturing motor vehicle parts and engines or rebuild motor parts. NAICS 336211 (Motor Vehicle Body Manufacturing) includes establishments that focus on manufacturing automobile bodies.

8. The National Electric Vehicle Infrastructure (NEVI) Formula Program was created in 2021 by the Bipartisan Infrastructure Law to build a national network of EV charging stations. In February 2025, the US Federal Highway Administration put the NEVI Formula Program under review and paused funding to help states build out EV charging infrastructure. In August 2025, after a funding pause and a legal battle, the program was resumed with revised guidance from the Trump administration (Kim 2025).

9. The USEER provides a comprehensive summary of national-, state-, and county-level energy jobs, reported by industry, technology, and region, with data on unionization rates, demographics, and employer perspectives on growth and hiring (DOE and BW Research 2024). The USEER is based on data from the BLS and supplementary surveys of US energy sector employers. As part of the broader USEER data collection process, the research team surveys automotive employers (identified by NAICS codes) and asks employers to allocate their employees by the automotive technology (ICEV, EV, fuel cell EV, etc.) they most commonly work with. The research team then uses representative sampling to extrapolate quantitative estimates for the total size of the workforce involved in the respective technologies.

10. The remaining employment tracked by the USEER is largely covered by hybrid EVs and PHEVs.

11. Separating the impacts of automation and the BEV transition is a significant challenge for the automotive industry because the two trends are closely intertwined and mutually reinforcing. As a result, comprehensive studies that fully untangle their respective effects are rare.

12. Based on announced job numbers reported in publicly available announcements that could change over time. The EV Jobs Hub, built by Atlas Public Policy and the BlueGreen Alliance Foundation (2025), tracks announced manufacturing-specific jobs in EV assembly, manufacturing of vehicle components, battery production, battery recycling, minerals processing, and EV charger manufacturing.

13. Upskilling involves training workers to meet the changing requirements of their current roles. Reskilling involves training workers on entirely new skills in an entirely different role or field.

14. The main difference between an ICEV and a BEV transmission is how power is generated and delivered. ICEVs require a multigear transmission that can adjust the engine's power to different driving conditions. In BEVs, electric motors can deliver maximum power instantly across a wide range of speeds. This eliminates the need for multiple gears and makes for simpler, more efficient transmission systems.

15. BLS projections for industry and occupational employment are developed in a series of six interrelated steps (labor force, aggregate economy, final demand or GDP by consuming sector and product, industry output, industry employment, and employment by occupation), each of which is based on a different procedure or model and assumptions. Because individual estimates are generated for each BLS demand sector, the BLS does not publish an estimate for overall economic growth (BLS 2024a, 2024b). The Congressional Budget Office, however, estimates an annual GDP growth rate of 0.1–1.8 percent for 2023–33 in its 2023–33 budget and economic outlook (CBO 2023).

16. The research team identified common occupations employed within NAICS codes, such as NAICS 336310 (Motor Vehicle Gasoline Engine and Engine Parts Manufacturing), using BLS industry-occupation matrix estimates (BLS 2023d). This BLS resource provides a breakdown of employment in different NAICS code industries by occupations based on the BLS Standard Occupational Classification (SOC) system, which is a statistical standard used by federal agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data (BLS n.d.). Under the SOC framework, SOC code 51-0000 depicts production occupations covering jobs that involve the creation, assembly, and processing of goods, and SOC code 17-0000 depicts engineering occupations covering jobs such as engineers or technicians who apply scientific and technical principles to design, build, and analyze systems and structures.

17. Table 7 only shows engineering occupations that are currently prevalent within the gasoline engine and engine parts manufacturing industry (NAICS 336310). Other engineering occupations, such as electrical engineers and computer engineers, which are likely to see growth due to the transition to BEVs, are shown in Table D-4 (Appendix D).

18. The DOE expects North America's battery manufacturing capacity to increase to nearly 1,000 gigawatt-hours per year by 2030 from 55 gigawatt-hours per year in 2021.

19. For this survey question, respondents who chose "Other" mentioned occupations such as tow truck operators, roadside assistance providers, and fuel station attendants equipped with BEV-specific knowledge. The "Other" category also included more generic responses (i.e., "new BEV workers," "new hires," "trainees," etc.) that could not be classified into a specific occupational category.

20. Automated technologies are those that are designed to perform tasks with programmed commands and reduced human intervention. The purpose is to reduce human labor, increase efficiency, and ensure standardized quality in a repetitive manner. Although this report discusses how the firms in the survey sample are planning to incorporate greater automation in their activities, further evaluation is required to determine the role of automation in the US economy and understand trends and implications across different industries.

21. Digital technologies include the software, hardware, networks, and digital data used to store, process, and transmit information. Digital technologies enable automation.

22. A couple of other studies have also shown that Black workers represent a higher share of workers in the auto industry compared to the wider economy (Barrett and Bivens 2021; Coffin and Lawrence 2020).

23. O*NET OnLine's related occupations are developed using task- and detailed work activity–based similarity, knowledge importance similarity, and alternate title similarity data. See Dahlke et al. (2022) for a full methodology.

24. The O*NET Degree of Automation data set measures the prevalence of automation in a given occupation and is developed using detailed work context and work activity data.

25. Following negotiations with the UAW, an agreement was reached in late 2023 to reopen the plant in 2027 to build a new midsize truck. Stellantis has not revealed whether the truck will be a gas-powered, fully electric, or hybrid vehicle (Avila 2025).

26. The WARN Act of 1988 requires employers with 100 or more employees to provide notification 60 days in advance of plant closings and mass layoffs.

27. Led by the Michigan Alliance for Greater Mobility Advancement, the EV Jobs Academy is an employer-led collaboration between more than 100 stakeholders, including leading employers and educational institutions, to identify the occupational and skill needs for the EV industry (Gagnon Rodriguez and Trousdale 2024; LEO n.d.). The EV Jobs Academy is managed by the Sector Strategies Team within LEO's Office of Employment and Training. The Sector Strategies initiative is a demand-driven model to address the needs of employers within an industry or a specific geographic region and build talent pipelines, addressing skill gaps and creating career pathways for workers (LEO n.d.). The grant for the EV Jobs Academy was awarded by LEO's Office of Employment & Training and the Michigan Economic Development Corporation to the Southeast Michigan Community Alliance's Workforce Intelligence Network in 2022.

28. There is no comprehensive database for registered apprenticeships. Although the US Department of Labor maintains a data system that provides some information, a significant data gap exists because some states may not submit the information. The existing data also do not provide information on employment outcomes by demographic group. Improving data collection is a necessary first step to gain a better understanding of how these programs are working.

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