BUILDING AN ELECTRIC TRANSPORTATION SUPPLY CHAIN IN THE UNITED STATES

COMPANIES, JOBS, GROWTH RATES, AND ECONOMIC OPPORTUNITIES IN VEHICLE ELECTRIFICATION

Prepared by BW Research Partnership

August 2021

*Electric Vehicles are powering the Nation's economy. **That's** the power of now.*

The Power of NOW

ADVANCED ENERGY ECONOMY

ACKNOWLEDGMENTS

This report was prepared for Advanced Energy Economy by BW Research Partnership. BW Research is a full-service consulting and research firm specializing in workforce and economic development for public entities, including workforce investment boards, economic development agencies, cities, counties, and educational institutions.

BW Research has substantial experience developing customized research projects and a deep understanding of the clean energy sector and its employers, workforce, and supply chain dynamics. BW Research has designed and conducted more than 500 studies for public, private, and not-for-profit organizations globally, and our projects have directly impacted federal, state, and local initiatives. Our research, employer engagement, ideation services, and facilitation have produced tangible results across the world.

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About Advanced Energy Economy

Advanced Energy Economy (AEE) is a national association of businesses that are making the energy we use secure, clean, and affordable. AEE is the only industry association in the U.S. that represents the full range of advanced energy technologies and services, both grid-scale and distributed. Advanced energy includes energy efficiency, demand response, energy storage, wind, solar, hydro, nuclear, electric vehicles, and more. AEE's mission is to transform public policy to enable rapid growth of advanced energy businesses. Engaged at the federal level and in more than a dozen states around the country, AEE represents more than 100 companies in the $240 billion U.S. advanced energy industry, which employs 3.2 million U.S. workers. Learn more at www.aee.net and follow the latest industry news @AEEnet.

EXECUTIVE SUMMARY

Advanced Energy Economy engaged BW Research Partnership to examine the current and potential Electric Transportation (ET) economy across the United States. This research focuses on the current businesses and workers involved in the ET supply chain and examines the economic opportunities as the electrification of transportation continues. There are notable strengths in the ET supply chain across the U.S., including automobile and component parts manufacturing, a robust electrical component manufacturing sector, a growing network of charging stations and equipment providers, and a large workforce trained in traditional vehicle manufacturing, which could readily provide workers as the ET economy expands. There are other areas in which the ET sector's growth may be constrained, including the production of batteries and advanced semiconductors. Through intentional policies, the U.S. can leverage its position as the global leader in innovation and development to reduce or remove these barriers and facilitate rapid electrification of transportation.

This study begins with an overview of the current ET supply chain in the U.S., including the current number of jobs and businesses involved in ET, historical growth rates, and projections of near-term growth. The research then identifies "Adjacent Industries and Occupations," which are firms and workers that are not currently involved with ET goods or services but have characteristics similar to those that are. Examining Adjacent Industries and Occupations is useful for identifying existing companies and workers that could transition from one industry to another with relative ease. This analysis is also useful in highlighting some industries that may benefit from increased demand for their products driven by the rise in ET.

For the purposes of this research, the ET supply chain includes any firm involved in the manufacturing, wholesale distribution, retail sale, installation, research and development, and maintenance of ET vehicles and equipment (including automobiles, light and heavy-duty trucks, buses, industrial equipment, agricultural equipment, rail, recreational vehicles, and other ET) component parts (including battery, motor controller, electric engine, regenerative braking, and drive system components), and the infrastructure necessary for ET (including charging stations and associated storage and component parts).

Key Findings

In 2019 there were an estimated 15,200 businesses with 155,000 workers involved in ET-related activity across the country. These workers and businesses can be found in all 50 states, as well as in Washington, D.C. The number of ET-related workers is projected to nearly double during the five years that follow, reaching 296,000 workers by 2024.

There are 2.1 million workers in Immediate Adjacent and Secondary Adjacent Manufacturing Industries. Workers in these Adjacent Industries have skillsets that would allow them and the companies they work for to transition to ET-related work with little additional training or upskilling required. The similarities in knowledge and skillsets suggest that ET-related jobs could offer a lifeline to workers in Immediate Adjacent Manufacturing Industries, which saw more than 15,000 jobs disappear in Michigan, Ohio, and Kansas alone between 2014 and 2019.

ET activity is estimated to have contributed $29 billion in Gross Domestic Product (GDP) in 2019. This is roughly equivalent to the GDP contributions of Architectural Services, Surgical and Medical Instrument Manufacturing, and Automotive Parts and Accessories Stores.

Manufacturing is a large component of the ET value chain. Four in 10, or roughly 61,000, ET-related jobs are in Manufacturing. Repair & Maintenance and Wholesale Trade, Distribution, and Transportation also account for substantial portions of the ET value chain.

The U.S. ET sector is primed to grow rapidly, but supply chain bottlenecks in components, such as lithium-ion batteries and semiconductors, may hinder this growth. While many aspects of the U.S. ET supply chain are prepared for a significant increase in demand, lithium-ion batteries and specialized microchips have the potential to act as constraints. Expanding domestic production of these advanced technologies can make supply chains more resilient while bolstering the nation's innovation economy.

Incentive programs to accelerate demand and support domestic manufacturing will grow the industry and improve the domestic supply chain. Tax credits and other

incentives for the purchase of light-, medium-, and heavy-duty electric vehicles, as well as charging equipment, will accelerate broad EV adoption by households, businesses, and governments. Additionally, policies that support manufacturers of EVs and key supply chain components will further incentivize domestic growth and job creation.

Policy Recommendations

Expand and fully fund consumer and business incentives programs. Extending and expanding existing tax credits for light-duty EVs and associated charging infrastructure will help foster broad EV adoption.

Increase the national fleet of electric school buses by providing incentives. By offering financial incentives to schools for the purchase of electric school buses and the associated charging equipment, the country could capitalize on the many benefits of electric school buses, including improved air quality within communities and cost savings for school districts. Incentive programs should be especially focused in areas disproportionately impacted by poor air quality and in school districts with the greatest financial need.

Electrify government-owned fleets, including transit fleets. Governments can use procurement powers to affordably electrify their fleets, stimulate the economy, create fuel savings, and improve public health.

Expand programs aimed at bolstering domestic manufacturing of EVs and critical supply chain components. Supporting the transition of the domestic automotive industry to electrified transportation will ensure that the U.S. remains globally competitive and retains domestic manufacturing jobs. Manufacturers who source and retain high domestic content should be rewarded with additive beneficial policies.

Expand the availability of workforce development programs, such as Electric Vehicle Infrastructure Training Program (EVITP) and other public and private certification courses, across the country. Further workforce trainings are an important tool that helps expedite the development of skills needed to work on construction and maintenance related to EV charging infrastructure.

Additional considerations are needed to ensure retraining opportunities for affected workers. While the transition from internal combustion engine (ICE) vehicles

to EVs will largely transfer existing jobs and create new opportunities, some parts of the current automotive industry could face hardship. More than 63,000 people in the U.S. are employed in Motor Vehicle Gasoline Engine and Engine Parts Manufacturing, and demand for this work will decline as ICE vehicles comprise a smaller portion of vehicles produced and sold. Efforts that examine these workers' skills and transition opportunities will be essential in fostering an ET economy that benefits all Americans.

Bolster research and development and "moonshot" initiatives. America's research and development (R&D) institutions have the reputation for being the best in the world. Leveraging these assets to push the frontiers of technology and remove barriers will be crucial in making ET more cost-effective and supply chains more robust. Opportunities for R&D initiatives that are focused on lithium and rare earth metal mining and extraction, advanced battery technologies and materials, and advanced semiconductor design and production will help ensure that the ET supply chain is resilient, reliable, and geared towards technologies of the future.

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INTRODUCTION

Advanced Energy Economy commissioned BW Research Partnership to examine the characteristics of the Electric Transportation (ET) supply chain across the United States. The research in this report quantifies existing companies involved in ET and the workforce that supports them. This report also includes a section focused on Adjacent Industries that could benefit from increased ET activity. For the purposes of this study, the ET sector is defined as any firms involved in the manufacturing, wholesale distribution, retail sale, installation, research and development, maintenance and repair of electric vehicles (EVs) and equipment (including automobiles, light and heavy-duty trucks, buses, industrial equipment, agricultural equipment, rail, recreational vehicles, and other ET), component parts (including battery, motor controller, electric engine, regenerative braking, and drive system components), and the infrastructure necessary for ET (including charging stations and their component parts). Due to the volatility within labor markets induced by the coronavirus pandemic, this report primarily relies on 2019 data to serve as a baseline.

To develop the data for this report, BW Research built a comprehensive database of 200,800 businesses potentially involved in ET work. BW Research closely examined 32,800 businesses within this dataset, prioritizing manufacturing operations. BW Research confirmed 1,155 firms with 1,631 unique locations with current involvement in the ET sector. Based on this sample, BW

Sample of ET Companies

AllCell Technologies
Blue Bird
EnTech Solutions
EVgo
Dana Incorporated
Denso Manufacturing
Harley-Davidson
Hickok Waekon
Highland Electric Transportation
LG Energy Solutions
Lion Electric
Lucid Motors
Magna International
Rivian
SK Innovation
Tesla
Ultium Cells

Research estimates that there are 15,200 businesses involved in some form of ET-related activity across the U.S.

It is important to note that ET-related growth creates net new jobs in some segments of the economy while minimally or negatively impacting others. Manufacturing makes up a substantial part of the ET-related workforce, and it is most likely to generate additional employment through increased demand for products. For example, EVs use up to 10 times more semiconductors than internal combustion vehicles.[1] This presents enormous potential for job creation for production of these parts. Conversely, among occupations in sales, service, and other downstream jobs, new ET activity is more likely to replace work currently focused on non-ET activities rather than creating new jobs. This results in fewer net new jobs created in downstream roles than in manufacturing.

The ET economy in the U.S. touches a range of industries. The broad nature of the ET sector emphasizes the importance of understanding the current scale, workforce, and opportunities for continued growth and development. To capture some of this potential for growth, this report identifies the industries, companies, and workers that could readily transition to and benefit from an expanding ET market. Throughout this report, these areas of opportunity are referred to as "Adjacent" Industries and Occupations. Adjacent Industries provide similar goods or services and have workers who, along with Adjacent Occupations, often have overlapping knowledge, skills, and abilities to those currently involved in ET.

There are three types of Adjacent Industries identified in this report:

Immediate Adjacent Manufacturing Industries include companies that are very similar to those identified as ET companies. They are so similar that they share a federal industry classification code (six-digit NAICS). Transition to ET-related work would be most rapid for companies in Immediate Adjacent Manufacturing Industries. Examples of Immediate Adjacent Manufacturing include General Automobile Manufacturing,[2] Motor and Generator Manufacturing, and Other Electronic Component Manufacturing.

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[1] UBS Evidence Lab. UBS Evidence Lab Electric Car Teardown: Disruption Ahead? https://neo.ubs.com/shared/d1wkuDlEbYPjF/

[2] Throughout this report, industries and occupations that are capitalized refer to specific titles in the North American Industry Classification System (NAICS) and Standard Occupational Classification (SOC), respectively. For definitions of these industries and occupations, please see the Glossary in Appendix D.

Secondary Adjacent Manufacturing Industries include companies that are similar to existing ET companies, but less so than Immediate Adjacent Manufacturing Industries. These companies engage in the same general family of activities, but their transition to ET work would take more investment and time than for Immediate Adjacent Manufacturing Industries. Examples of Secondary Adjacent Manufacturing Industries include Relay and Industrial Control Manufacturing; Semiconductor and Related Device Manufacturing; and Power, Distribution, and Specialty Transformer Manufacturing.

Support Industries include companies that are upstream suppliers to companies in Adjacent Industries.[3] These include manufacturers as well as distributors and wholesalers. Growth in the ET market might require changes in operations, but as these firms tend to focus on raw materials and upstream components, those changes are likely to be minimal. These Support Industries are poised to greatly benefit from the growth of the U.S. ET supply chain. Examples include Plate Work Manufacturing, Iron and Steel Mills and Ferroalloy Manufacturing, and Machine Shops.

ELECTRIC TRANSPORTATION POLICIES IN THE UNITED STATES

Over the past 15 years, the federal government has gradually strengthened policy supporting electrification of the transportation sector. One of the most longstanding, consistently re-funded federal policies is the Advanced Technology Vehicles Manufacturing (ATVM) Loan Program, which provides manufacturers with loans to cover up to 30% of the cost of "re-equipping, expanding, or establishing" facilities to produce Advanced Technology Vehicles (ATVs) and ATV components, including electric vehicles and parts.[4] The program has loaned $8 billion to support projects that have produced over 4 million ATVs since its inception in 2007. In 2009, Ford was granted $5.9 billion in loans to upgrade 13 facilities in six states for producing

[3] Support industries do provide some raw materials to existing ET firms, but the small size of the current market has minimal relative impact.
[4] Reference 42 U.S. Code 17013 https://afdc.energy.gov/laws/411

a range of ATVs. The ATVM currently has authority to approve over $17.7 billion in loans.

Federal incentives are also available to facilitate the adoption of EVs by consumers. The Plug-in Electric Vehicle tax credit (PEV Credit), established in 2009, provides purchasers of new passenger EVs and light-duty electric trucks with a tax credit of $2,500 to $7,500 depending on battery capacity and vehicle weight rating.[5] The policy applies equally to all qualifying EVs until a manufacturer has sold 200,000 EVs, at which point the value of the credit applicable to that manufacturer's EVs is incrementally reduced over a one-year period until it is phased out entirely. GM and Tesla reached the 200,000-unit threshold in 2018-2019, but other major companies are still receiving credits; by the end of 2020, Nissan had reached about 148,000 qualifying EVs, Ford had sold 126,641, BMW had sold 111,542, and Mercedes-Benz 24,385. The 2021 proposed Electric CARS Act[6] would extend the PEV credit through 2031 and remove the per-manufacturer cap.

Several federal programs are also funding charging infrastructure and zero-emission freight development at scale. The Alternative Fuel Vehicle Refueling Property Credit—which the Electric CARS Act would also extend to 2031—reimburses taxpayers for up to 30% of the cost of purchasing and installing electric charging infrastructure on their property.[7] In 2021, the Department of Transportation's Infrastructure for Rebuilding America (INFRA) grant program will issue over $800 million to states, metropolitan areas, local governments, and tribal governments, to improve freight efficiency and build EV charging infrastructure along the National Highway System.[8] Additionally, two grants from the Department of Energy will award over $162 million for R&D to develop high-efficiency and electric tractor-trailer and other freight trucks.[9] [10]

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[5] P.L. 111-5 https://www.govinfo.gov/link/plaw/111/public/5

[6] S.395 https://www.congress.gov/bill/117th-congress/senate-bill/395?r=6&s=1

[7] 26 U.S. Code § 30C https://www.govinfo.gov/app/details/USCODE-2011-title26/USCODE-2011-title26-subtitleA-chap1-subchapA-partIV-subpartB-sec30C

[8] 86 FR 11572 https://www.federalregister.gov/documents/2021/02/25/2021-03885/notice-of-funding-opportunity-for-the-department-of-transportations-infrastructure-for-rebuilding

[9] DE-FOA-0002450, CFDA 81.087 https://eere-exchange.energy.gov/Default.aspx#FoaId890752f2-c1f2-4f10-8a8c-1dbb1fa80542

[10] DE-FOA-0002475, CFDA 81.086 https://eere-exchange.energy.gov/Default.aspx#FoaIdbba83da0-9b58-4d26-8c6a-4a36230aed4f

The federal government is also supporting the transition of federal, state, and local fleets and public transportation systems to Zero-Emission Vehicles (ZEV). Over the last five years, the Low or No Emission (Low-No) Vehicle Program has granted states and municipalities over half a billion dollars to invest in Low-No emission buses and infrastructure.[11] The program's annual funding has more than tripled since it was introduced in 2016. The Public Transportation Innovation program will give out $30 million in 2021 for public transportation R&D.[12] Executive Order 14008,[13] announced in January 2021, builds on the Energy Policy Act[14] of 1992's fuel mix standards for federal vehicles by tasking a group of agency heads to develop a plan for supporting a transition to ZEV fleets at the federal, state, and local levels. This plan is currently under review by the National Climate Task Force and the findings will be used as a framework for transitioning the federal fleet. A separate program, from the Federal Aviation Administration, currently provides airports with grants to upgrade onsite vehicle fleets to EVs.[15]

There are opportunities for federal policies currently under development to expand EV production. The proposed American Jobs Plan includes language that would commit $174 billion to growing the EV industry by way of consumer credits, financial support to EV manufacturers, and other programs with various targets, including constructing a national network of 500,000 EV chargers by 2030 with support for labor and training programs, replacing 50,000 diesel transit vehicles with EVs, and electrifying at least 20% of school buses.[16] The bipartisan infrastructure framework announced in June 2021 also provides support, at $15 billion, for electrifying school and transit buses and installing EV charging equipment.

The main barrier to growth in the U.S. EV industry, though, is the shortage of battery materials and advanced semiconductors. EVs use up to 10 times as many semiconductors as traditional vehicles.[17] Because of the highly specialized knowledge and manufacturing capabilities required to assemble these semiconductors and the

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[11] 49 U.S.C. 5339 (c) https://www.govinfo.gov/content/pkg/USCODE-2019-title49/html/USCODE-2019-title49-subtitleIII-chap53-sec5339.htm
[12] 49 U.S.C. 5312 https://www.transit.dot.gov/funding/grants/public-transportation-innovation-5312
[13] 42 U.S. Code 13212 https://www7.eere.energy.gov/femp/requirements/requirements_filtering/fleet_management?tid[]=27
[14] 42 U.S. Code 13257 https://www.govinfo.gov/app/details/USCODE-2019-title42/USCODE-2019-title42-chap134-subchapIII-sec13257
[15] 49 U.S. Code 47136a https://www.faa.gov/airports/environmental/zero_emissions_vehicles/
[16] https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/
[17] UBS Evidence Lab. UBS Evidence Lab Electric Car Teardown: Disruption Ahead? https://neo.ubs.com/shared/d1wkuDlEbYPjF/

wider set of components that comprise the EV powertrain, the supply chains for these components are currently quite rigid. Seventy percent of automotive chips are manufactured by one Taiwanese company.[18] The CHIPS for America Act, which passed the Senate in June 2021, aims to expand domestic chip manufacturing by providing manufacturers along the domestic semiconductor supply chain with direct financial assistance.

Recent progress has been made in domestic battery production, as companies such as Panasonic in Nevada; SK Innovation, under construction in Georgia; and LG Energy Solutions in Michigan, have lithium-ion battery production facilities across the U.S. The sourcing of lithium for these batteries is another challenge. Experimental extraction methods—such as pulling lithium from brine in the Salton Sea in California or harvesting dissolved lithium from seawater—show promise but will require additional research and development to scale and commercialize. If funding is directed to manufacturers of semiconductors and batteries commonly used in EVs, it would accomplish the goal of increasing domestic semiconductor and battery manufacturing while providing the EV industry with the supply of components it needs to grow.

POLICY RECOMMENDATIONS

EVs, and the technologies that support them, continue to face barriers to widescale expansion and adoption. In order to grow the EV market, remove supply chain bottlenecks, and fully capitalize on ET economic opportunities, the United States must take regulatory and legislative action.

Policies that support ET adoption and reinforce its supply chain can help the ET sector quickly scale. In addition to the employment and economic development opportunities provided by the ET supply chain, EVs can provide cost savings for all electric ratepayers, regardless of whether they own an EV. They also provide operational and maintenance cost savings for their owners and increased energy security as they shift

[18] IHS Marketplace. "Managing the 2021 Automotive Chip Famine." Feb 2, 2021.

transportation energy use from petroleum fuels to clean electricity generation, which often comes from local resources.

These benefits create a clear need for thoughtful policy that cuts across multiple areas of concern, including electric utility regulation, transportation policy, supply chain security, and workforce development. To facilitate this process, the U.S. should consider the following policies to support its ET supply chain:

Expand and fully fund consumer and business incentives programs. Extending and expanding existing tax credits for light-duty EVs and electric vehicle charging infrastructure will help foster broad EV adoption. These credits include the section 30C tax credit for electric vehicle charging stations, which should be modified to raise the allowable credit per item (Securing America's Clean Fuels Infrastructure Act[19]), and the section 30D tax credit, which should be modified to remove the per-manufacturer cap and make the credit more accessible (Electric CARS Act[20]). Ensuring that EV incentives and charging infrastructure are accessible to all communities is also critical. In addition to these existing incentives, creating refundable tax credits for medium- and heavy-duty EVs and improving incentives for businesses that transition their fleets will accelerate uptake across all classes of EVs.

Increase the national fleet of electric school buses by providing incentives. Presently, financial barriers impede the adoption of electric school buses. By offering financial incentives to schools for the purchase of electric school buses and the associated charging equipment, the country could capitalize on the many benefits of electric school buses, including improved air quality within communities and cost savings for school districts. Incentives should be based on the level of financial aid that a school district received in the previous fiscal year, with higher incentives going to higher-needs school districts. The Clean School Bus Act provides a potential model.[21]

Electrify government-owned fleets, including transit fleets. Federal, state, and local governments together account for millions of vehicles on the road. Governments can use procurement powers to affordably electrify their fleets, stimulate the economy,

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[19] https://www.congress.gov/bill/117th-congress/senate-bill/975
[20] https://www.congress.gov/bill/117th-congress/senate-bill/395/
[21] https://www.congress.gov/bill/117th-congress/senate-bill/506/

create fuel savings, and improve public health. Expansion and modification of the Low-No Vehicle Program at the Department of Transportation could support electrification of transit fleets (GREEN Buses Act[22]).

Expand programs aimed at bolstering domestic manufacturing of EVs and critical supply chain components. Supporting the transition of the domestic automotive industry to electrified transportation will ensure that the U.S. remains globally competitive and retains domestic manufacturing jobs. Reviving the 48C tax credit, fully funding the ATVM Loan Program, and creating additional incentives for domestic production of key supply chain components like lithium-ion batteries and semiconductors will all help facilitate these outcomes. Targeting these investments to preserve plants at risk of closure or rebuild existing manufacturing communities will maximize impact by putting dollars where expertise and facilities already exist.

Expand the availability of workforce development programs, such as Electric Vehicle Infrastructure Training Program (EVITP) and other public and private certification courses, across the country. Further workforce trainings are an important training tool that helps expedite the development of skills needed to work on construction and maintenance related to EV charging infrastructure. Various states across the country have EVITP opportunities, but bolstering accessibility by partnering with junior colleges, trade schools, and labor organizations such as the International Brotherhood of Electrical Workers (IBEW) can create a steady pipeline for the EV workforce.

Provide retraining opportunities for workers displaced by ET. While the transition to ET largely creates new jobs or transforms existing duties, some portions of the automotive industry will be negatively impacted by the rise of ET. One that will be impacted is Motor Vehicle Gasoline Engine and Engine Parts Manufacturing, which employs more than 63,000 people in the U.S. Examining the skillsets of these workers and developing and supporting transition opportunities for them will ensure that the rise of ET does not leave workers behind. Programs aimed at retraining and retaining

[22] https://www.congress.gov/bill/117th-congress/house-bill/3347/

current workforces will strengthen the supply chain and decrease the risk of closure of existing facilities.

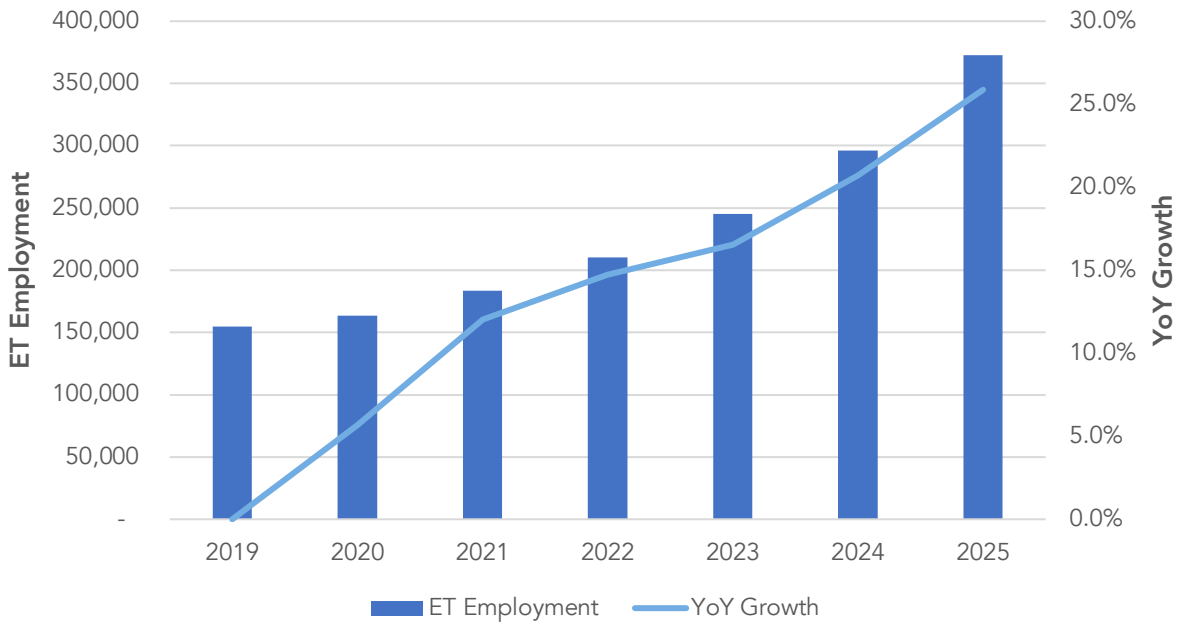
Bolster research and development and "moonshot" initiatives. America's research and development (R&D) institutions have the reputation for being the best in the world. Leveraging these assets to push the frontiers of technology and remove barriers will be crucial in making ET more cost-effective and supply chains more robust. Opportunities for R&D initiatives that are focused on lithium and rare earth metal mining and extraction, advanced battery technologies and materials, and advanced semiconductor design and production will help ensure that the ET supply chain is resilient, reliable, and geared towards technologies of the future.

THE ELECTRIC TRANSPORTATION WORKFORCE

ET-related employment in the U.S. is projected to nearly double between 2019 and 2024,[23] representing an additional 141,000 jobs. Year-over-year growth is expected to accelerate as EV adoption grows; ET employment is expected to grow by 12% between 2020 and 2021 and grow by 26% between 2024 and 2025 (Figure 1).

[23] This definition is based on a worker spending any time on electric transportation goods or services.

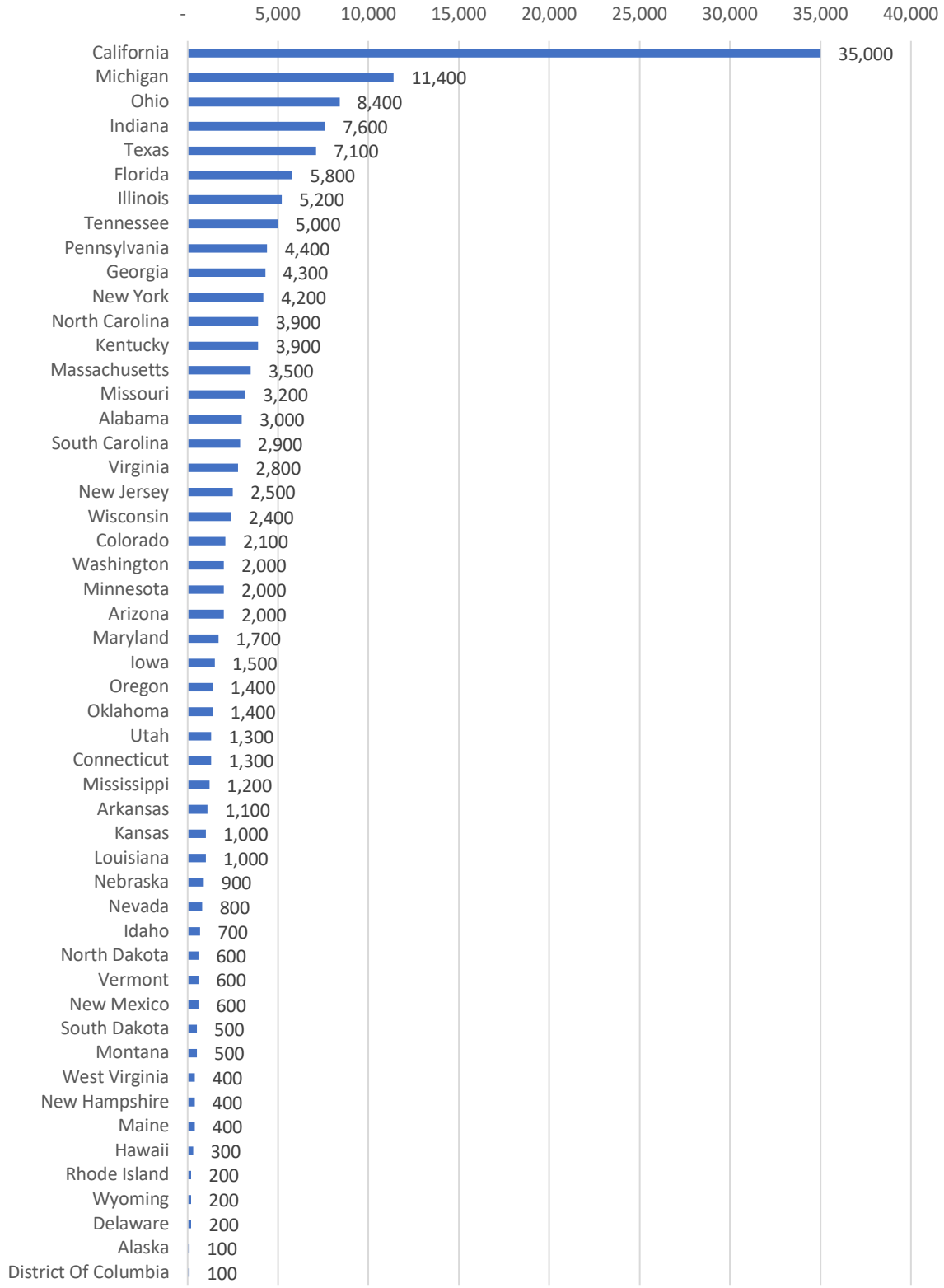
Figure 1: Projected ET Employment[24]



ET-related jobs can be found all 50 states. California (35,000), Michigan (11,400), and Ohio (8,400) are the three states with the greatest current number of workers involved in ET. Even the states with the fewest ET-related workers—Alaska, Delaware, and Wyoming—have between 100 and 200 workers involved in ET activity (Figure 2).

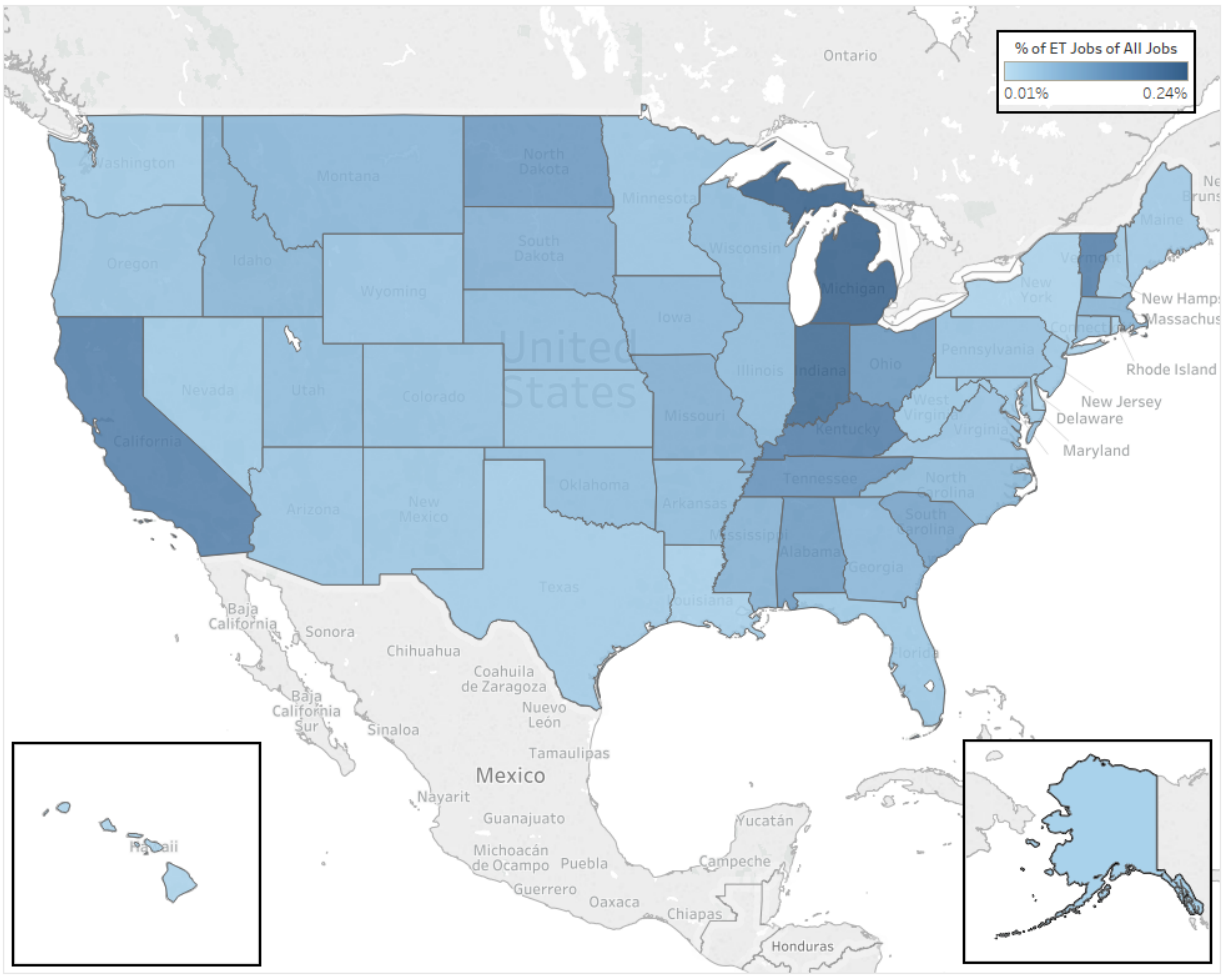
[24] This definition includes Battery-Electric Vehicles (BEVs) and Plug-in-Hybrid Electric Vehicles (PHEVs). ET employment projections developed with sales projections produced by EVAdoption and Loren McDonald. https://evadoption.com/ev-sales/ev-sales-forecasts/

Figure 2. ET-Related Employment, 2019



ET-related jobs make up a significant portion of all jobs in several states. Michigan, Indiana, Vermont, Kentucky, California, Tennessee, Ohio, North Dakota, Alabama, and South Carolina are the ten states with the highest proportion of ET workers relative to the overall number of workers. Some states, like Michigan, Ohio, Indiana, Kentucky, and Tennessee are traditional auto and parts manufacturing powerhouses. Other states, such as Vermont and North Dakota, have relatively small labor markets and strong specific segments of the ET value chain (Repair and Maintenance in Vermont due to high market share of EVs, and Wholesale and Distribution in North Dakota). In Michigan and Indiana, roughly 2.3 jobs out of every 1,000 are involved in ET activity (Figure 3).

Figure 3. Share of ET-Related Employment Relative to All Jobs



ET-related activity in the U.S. is estimated to have generated nearly $29 billion in Gross Domestic Product (GDP) in 2019. This amount is roughly equivalent to the GDP contributions of Architectural Services, Surgical and Medical Instrument Manufacturing, and Automotive Parts and Accessories Stores.

Manufacturing accounts for four of every ten jobs involved in ET. Repair & Maintenance, and Wholesale Trade, Distribution, & Transportation are the two other large segments of the ET value chain, accounting for 27% and 21% of all ET-related workers (Table 1).

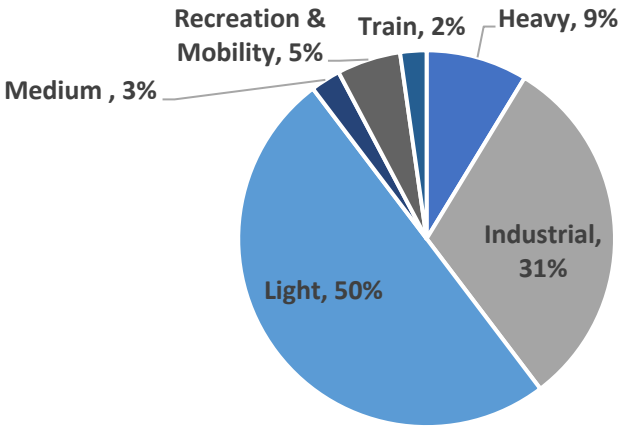
Table 1: ET-Related Employment by Value Chain

	Employment	Share of Employment
Manufacturing	61,103	39%
Repair & Maintenance	41,454	27%
Wholesale Trade, Distribution, & Transport	33,101	21%
Installation	7,189	5%
Professional and Business Services	6,360	4%
Retail Trade	5,798	4%

Half of all businesses are involved in light-duty[25] vehicles. Nearly a third of businesses identified were involved in Industrial vehicles, including forklifts and other off-road applications. About one-in-ten (9%) businesses have products that are heavy-duty vehicles, including school busses, tractor-trailer trucks, and other heavy trucks. Another 5% of firms work on Recreation and Mobility vehicles, such as scooters, bikes, and golfcarts (Figure 4).

[25] Based on Federal Highway Administration Definitions. https://afdc.energy.gov/data/10380

Figure 4. Share of Companies by Type of Vehicle Classes[26]



Automotive Service Technicians and Mechanics, Team Assemblers, and Autobody and Related Repairers are among the most common key ET-related occupations. All of these Key ET occupations are projected to grow between 2019 and 2024; the number of ET-related Team Assemblers is projected to increase by nearly 9,000 jobs alone (Table 2).

Table 2: Key ET Occupations

Key Occupations[27]	2019 ET Jobs	Projected 2024 ET Jobs[28]	Median Hourly Wage
Automotive Service Technicians and Mechanics	12,830	18,407	$21.20
Team Assemblers (including Miscellaneous Assemblers & Fabricators)	20,436	29,423	$16.15
Automotive Body and Related Repairers	4,514	6,374	$21.83
Laborers and Freight, Stock, and Material Movers, Hand	3,643	5,537	$14.95
Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	3,386	4,765	$29.86

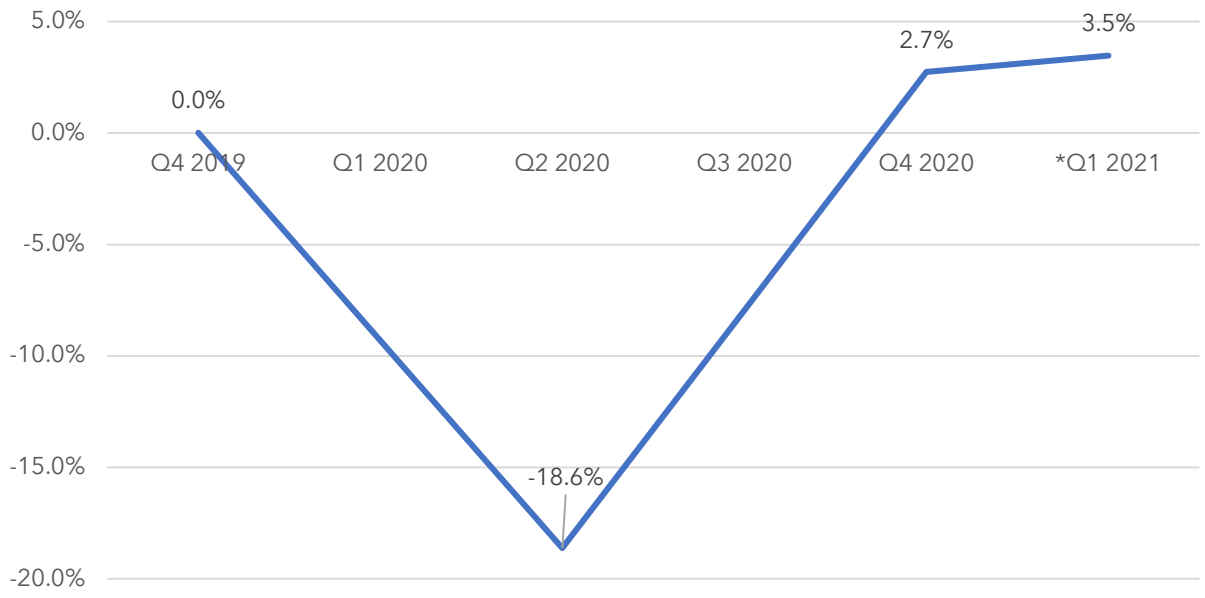
[26] In cases where companies operate in more than one vehicle class, the class responsible for the majority of business activity was assigned.
[27] Key occupations were identified based on total current employment within ET.
[28] Projected jobs are extrapolated from BLS OES occupational projections through 2024 and ET industry projections developed using data from the 2019 United States Energy and Employment Report, BLS QCEW, and EVAdoption.

Light Truck Drivers	3,195	4,799	$17.84
Office Clerks, General	2,683	3,890	$16.97
General and Operations Managers	2,384	3,606	$49.86
Welders, Cutters, Solderers, and Brazers	2,242	3,268	$21.25
Inspectors, Testers, Sorters, Samplers, and Weighers	2,133	3,194	$19.47

IMPACTS OF COVID-19

After the loss of nearly one-in-five clean vehicle jobs during the second quarter of 2020, clean vehicle employment has rebounded above pre-pandemic levels. Since the early days of the pandemic, BW Research has been tracking the changes in advanced energy employment across the United States.[29] The models developed by BW Research suggest that nationwide clean vehicle employment,[30] which includes EVs, declined by nearly 19% during Q2 of 2020. Over the course of the following six months, clean vehicle employment recovered, and is now almost 4% greater than before the pandemic (Figure 5).

Figure 5. COVID-19-Related Employment Losses in Clean Vehicles[31]



[29] https://bwresearch.com/covid/docs/BWResearch_CleanEnergyJobsCOVID-19Memo_Dec2020rev.pdf

[30] This definition includes hybrid electric vehicles, plug-in hybrid vehicles, electric vehicles, natural gas vehicles, hydrogen vehicles, and fuel cell vehicles.

[31] https://e2.org/wp-content/uploads/2021/04/E2-2021-Clean-Jobs-America-Report-04-19-2021.pdf

* Q1 2021 estimate developed through propriety model.

Company Snapshot

EVgo
Numerous States

Founded in 2010 and headquartered in Los Angeles, EVgo owns and operates the nation's largest public fast charging network for electric vehicles (EVs), and the first to be powered by 100% renewable electricity. With more than 800 fast charging locations in more than 65 metropolitan areas across 34 states, EVgo serves more than 250,000 active customers. The EVgo team currently includes approximately 200 employees across the U.S.

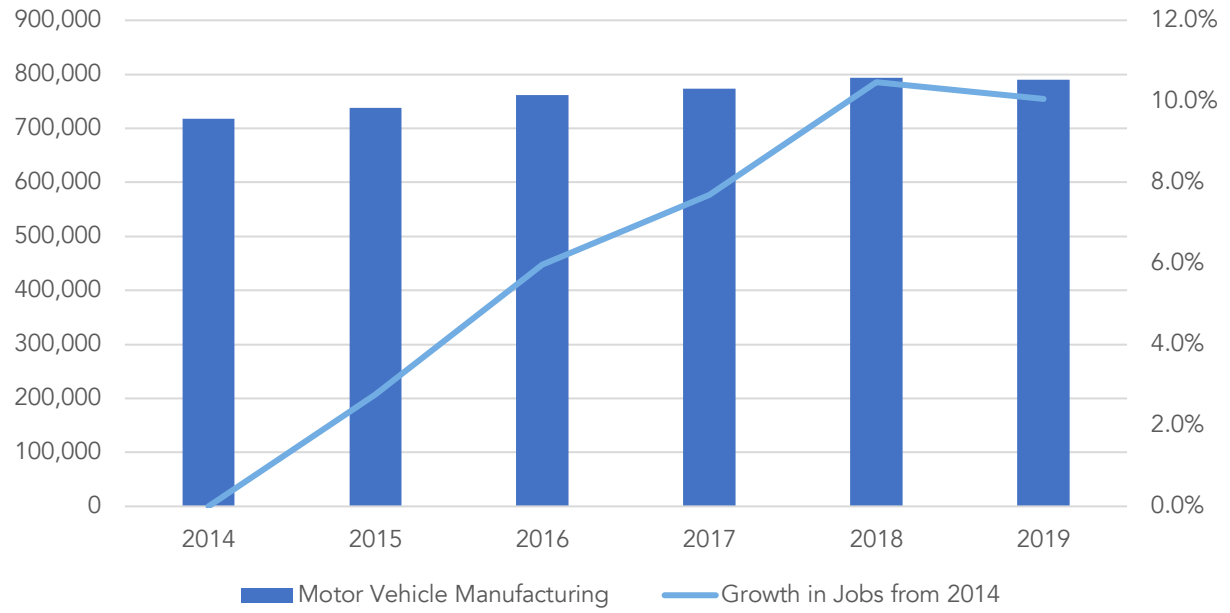
For both its public charging network and fleet charging solutions, EVgo employees serve across a range of functions, all dedicated to the acceleration of transportation electrification with best-in-class technology and reliability. Those functions include, but are not limited to, site acquisition, engineering and design, business development, construction management, field operations, and customer service. In addition to their employees, EVgo also works with a large network of contractors to install and maintain their charging network, which boasts a 98% uptime.

EVgo is a first mover and first learner in transportation electrification and has long been a partner of first choice for leaders like General Motors, Nissan, BMW, Lyft, Uber and others. The company continues to grow and expand with a commitment to add thousands of additional chargers to the EVgo public network over the next few years and ramping up fleet electrification efforts for delivery and logistics partners.

KEY TRENDS IN MOTOR VEHICLES

Motor Vehicle Manufacturing[32] jobs increased by 10% between 2014 and 2019,[33] faster than the rest of the U.S. economy during this time. This growth represents an additional 72,300 jobs (Figure 6). Other Motor Vehicle Parts Manufacturing and Automobile Manufacturing, which includes the final assembly of vehicles, each account for more than 130,000 jobs across the country (Figure 7).

Figure 6. Motor Vehicle Manufacturing Employment[34]

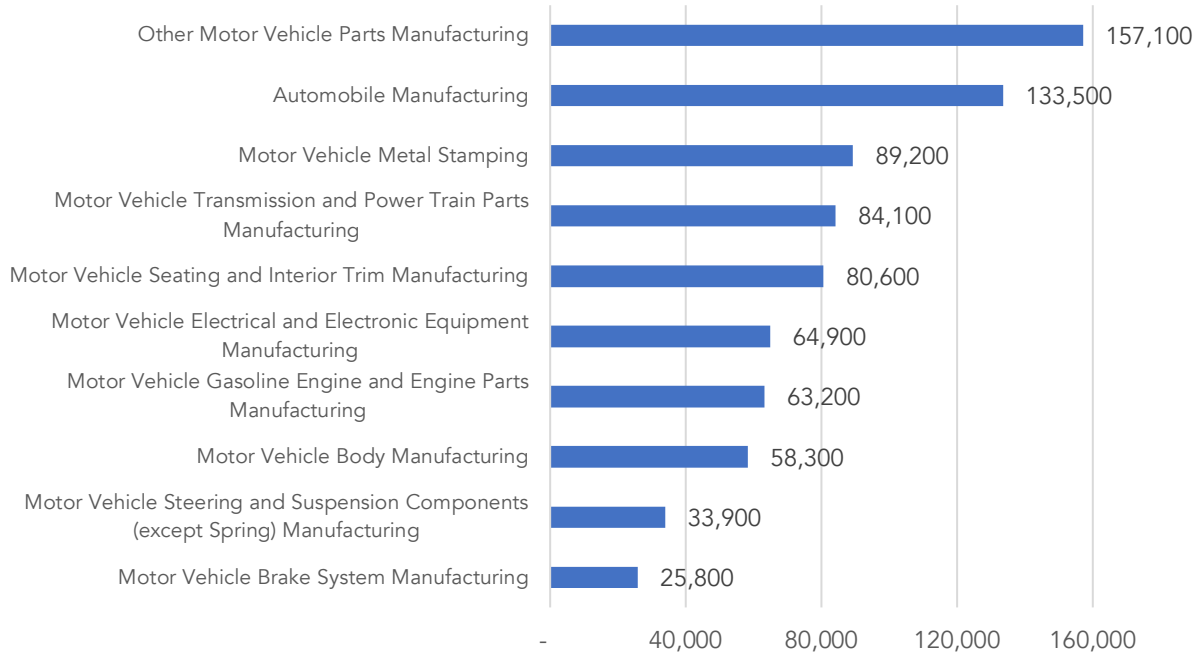


[32] This includes 10 NAICS centered around traditional automobile manufacturing. These NAICS codes are: 336111, 336211, 336310, 336320, 336330, 336340, 336350, 336360, 336370, and 336390.

[33] 2019 is used as the primary reference year throughout this report due to the volatility in labor markets that the pandemic caused throughout 2020.

[34] Ibid.

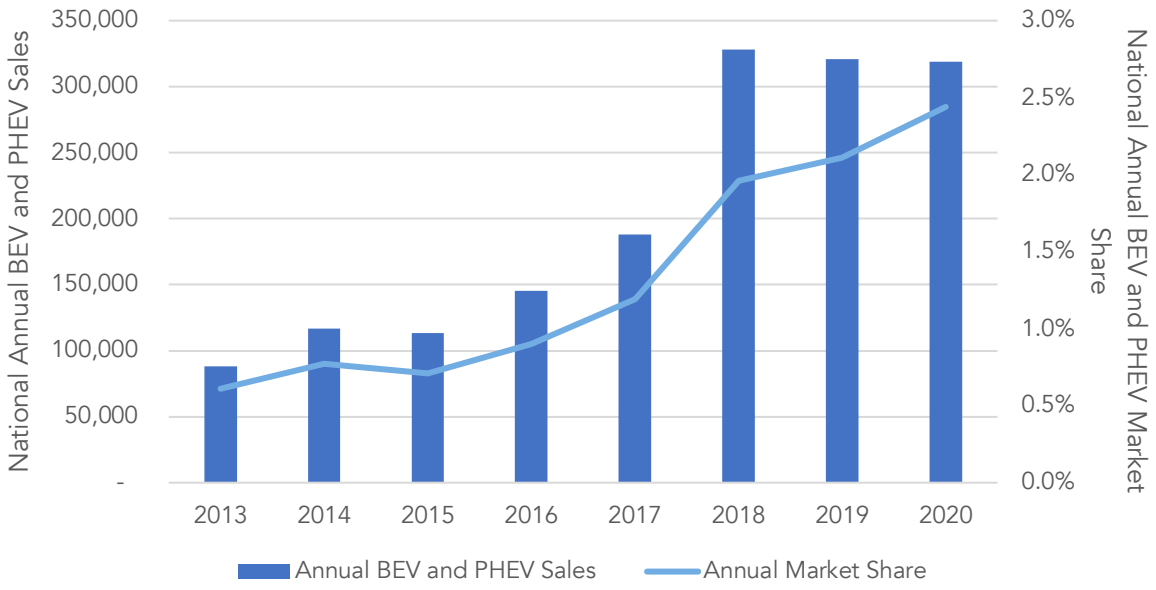
Figure 7. Motor Vehicle Manufacturing Jobs by Specific Industry, 2019[35]



[35] Sub-industry by six-digit NAICS code. JobsEQ

Battery-electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) account for an increasing share of vehicles sold in the United States. In 2020, EVs[36] accounted for nearly 2.5% of all light-duty vehicles sold, and the total number of EV sales were nearly 3-times greater in 2020 than in 2015 (Figure 8). It is also notable that while the total number of vehicle sales in the U.S. declined by 15%[37] between 2019 and 2020, EV sales only declined by 0.6%. Projections suggest this growth will continue as the cost of EV ownership continues to decline and charging infrastructure becomes more widely available.[38]

Figure 8. Annual Sales and Annual Market Share of EVs[39]



[36] Including Battery-Electric Vehicles (BEVs) and Plug-in-Hybrid Electric Vehicles (PHEVs).

[37] Total Vehicle Sales. Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/TOTALSA

[38] https://evadoption.com/ev-sales/ev-sales-forecasts/

[39] Includes BEV (Battery electric vehicles, which run exclusively on electric fuel) and PHEV (Plug-in hybrid electric vehicles, which run on either or both gasoline and electric fuel). Data from: Alliance of Automobile Manufacturers (2019). Advanced Technology Vehicle Sales Dashboard. Data compiled by the Alliance of Automobile Manufacturers using information provided by HIS Markit (2011-0218) and Hedges & Co. (2019). Data last updated 2/3/2021. Data retrieved March 23, 2021, from https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard

Company Snapshot

Rivian

Numerous States

Rivian is an independent U.S. manufacturer of all-electric trucks, SUVs, and delivery vans, with centers of gravity in Michigan and California, and a manufacturing facility in central Illinois. In 2021, the company will offer the R1T mid-size pickup and R1S seven-seater SUV. Both vehicles will eventually offer 400 miles of range. The company currently has 5,500 employees across the country, including nearly 2,000 in Normal, Illinois. Rivian also has a contract with Amazon to produce 100,000 electric delivery vans starting in 2021—the world's largest commercial EV fleet purchase in history. These delivery vans, along with the R1T and R1S, will be produced at the plant in Normal, a previously shuttered plant formerly owned and operated by Mitsubishi. By the end of the ramp-up period in early 2022, Rivian expects to have 2,700 manufacturing employees working at the plant in Normal. After securing over $2.6 billion in its most recent funding round, bringing the total funding to over $8 billion, Rivian is a startup that is poised to be a be a key EV industry player and a leading provider of ET jobs across the U.S.

ADJACENT INDUSTRY ANALYSIS

ET activity can be found across numerous industries. To best understand the scope and scale of some of the greatest opportunities in ET as the sector continues to grow, the research team identified "Adjacent Industries" that have similar workforce competencies, supply chains, and activities to current ET firms. Adjacent Industry and Occupational analyses help identify talent with similar or complementary skillsets that could easily transition to ET work from non-ET industries.

The Adjacent Industries identified in this report currently have little to no involvement in ET activities. Their importance lies in the workers, who have skillsets that would allow them to move into the ET supply chain with little training and transition with relative ease. Identifying these industries and their workers highlights a potential workforce that could easily support and grow with increased ET demand.

Adjacent Industries include three distinct categories: Immediate Adjacent Manufacturing Industries; Secondary Adjacent Manufacturing Industries; and Support Industries. For more information on these industry categories, see Appendix B: Industry Group Definitions.

- Immediate Adjacent Manufacturing Industries. This category includes the industries that share a federal industry classification code (six-digit NAICS) with ET manufacturing companies. Transition to ET-related work would be most rapid for companies in this category. Examples include Automobile Manufacturing, Motor and Generator Manufacturing, and Other Electronic Component Manufacturing.

- Secondary Adjacent Manufacturing Industries. This category includes industries in the same general industry classifications (four-digit NAICS codes) but differs at the more granular level (six-digit NAICS codes). These industries conduct the same family of activities as ET manufacturing firms, but their transition to ET work would take more investment and time than Immediate Adjacent Manufacturing Industries. Examples include: Semiconductor and Related Device Manufacturing, Other Aircraft Parts and Auxiliary Equipment Manufacturing, and Guided Missile and Space Vehicle Manufacturing.

- Support Industries. This category includes industries that are upstream of Immediate Adjacent Manufacturing Industries. They are typically industries that involve raw materials extraction and manufacturing. Growth in the ET market might require changes in operations, but since these companies tend to focus on raw materials and upstream components, those changes are likely to be minimal. Examples include: Plate Work Manufacturing, Iron and Steel Mills and Ferroalloy Manufacturing, and Bolt and Machine Shops.

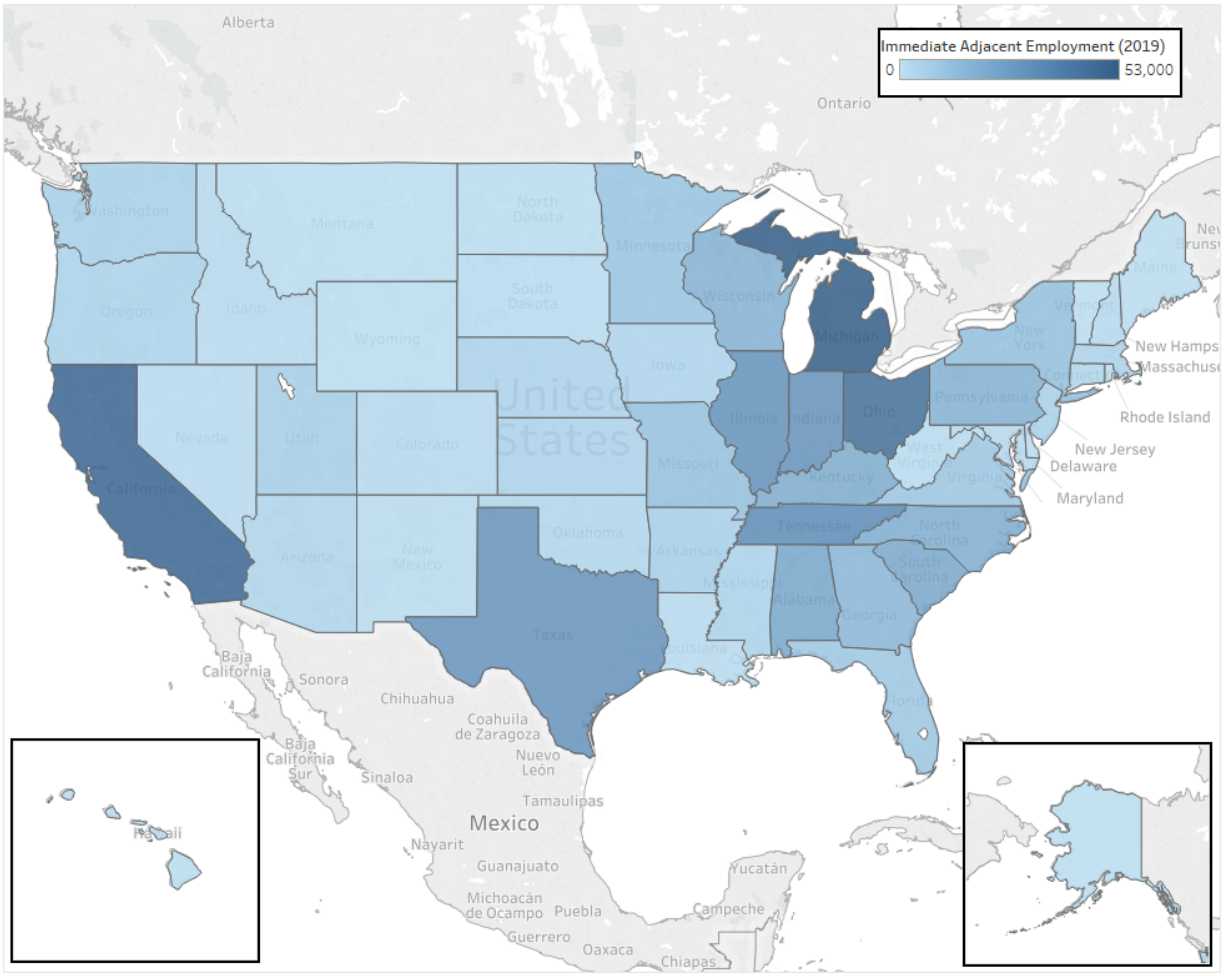
An Adjacent Occupational analysis is somewhat different from an Adjacent Industry analysis. Adjacent Occupational analyses focus on the types of workers that are most common within Adjacent Industries and examines their frequency throughout the entire statewide economy. This is a way of looking at Adjacent Industries through a workforce lens. Such an analysis identifies occupations with similar knowledge, skills, abilities, tasks, and other work activities, regardless of the industry in which the workers are currently in. The result is a list of occupations that share enough similarities such that the required workforce or on-the-job training to transition to an ET job would be minimal.

Immediate Adjacent Manufacturing Industries

Industry Analysis

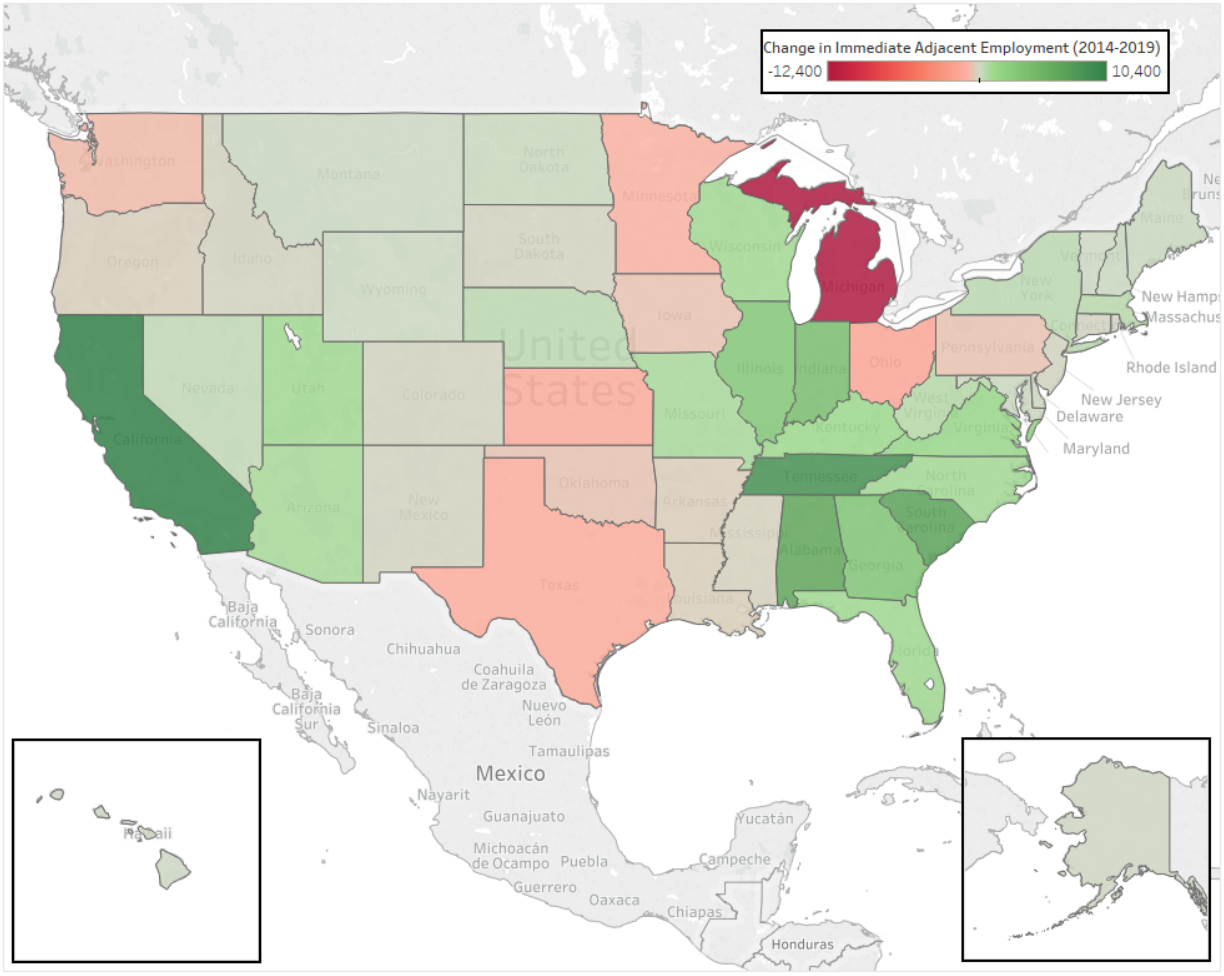
There are 537,300 workers across the country in Immediate Adjacent Manufacturing Industries (IAMI). Michigan (65,300 workers), California (38,800), and Ohio (47,100) are the states with the largest number of IAMI employees (Figure 9).

Figure 9: Immediate Adjacent Manufacturing Industry Employment, 2019



IAMI employment increased by 32,200 jobs between 2014 and 2019, led by growth in California, Tennessee, and South Carolina. However, IAMI employment decreased in 21 states, including Michigan (-12,400 jobs), Ohio (-1,600), and Kansas (-1,400) (Figure 10). Growth in ET activity could offer a lifeline to displaced IAMI workers in these states, as workers could transition to ET-related roles with little upskilling or additional training.

Figure 10: Change in Immediate Adjacent Manufacturing Industry Employment, 2014-2019



Occupation Analysis – A Workforce Perspective

This section looks at the most common occupations found among Adjacent Industries and tracks those occupations across all industries. These workers may work in non-Adjacent Industries, but their occupations mean they have skillsets that would allow them to feasibly transition to ET-related work.

The 10 most common occupations in Immediate Adjacent Industries account for more than 7 million jobs across all industries. Only one of these occupations has a typical entry-level education requirement beyond a high school diploma or equivalent, meaning that these occupations do not require extensive education and are accessible to a wide range of workers (Table 3).

Table 3. Key Immediate Adjacent Manufacturing Occupations

Key Occupations	2014 Jobs	2019 Jobs	Projected 2024 Jobs[40]	Typical Entry-Level Education	Median Annual Wages[41]
Laborers and Freight, Stock, and Material Movers, Hand	2,409,613	2,909,656	2,968,796	None	$32,100
Team Assemblers	1,054,840	1,144,259	1,001,760	High school diploma or equivalent	$34,800
First-Line Supervisors of Production and Operating Workers	621,694	646,883	608,271	High school diploma or equivalent	$65,200
Inspectors, Testers, Sorters, Samplers, and Weighers	488,862	573,214	516,629	High school diploma or equivalent	$43,000
Welders, Cutters, Solderers, and Brazers	395,393	432,206	414,541	High school diploma or equivalent	$45,200
Machinists	395,715	392,559	364,630	High school diploma or equivalent	$46,100
Electrical, Electronic, and Electromechanical Assemblers,	255,726	283,861	277,019	High school diploma or equivalent	$36,900

[40] These projections are from JobsEQ and based on occupation-specific growth across the state. They are not based on ET growth estimates.
[41] Wages do not include benefits, such as healthcare or dental insurance.

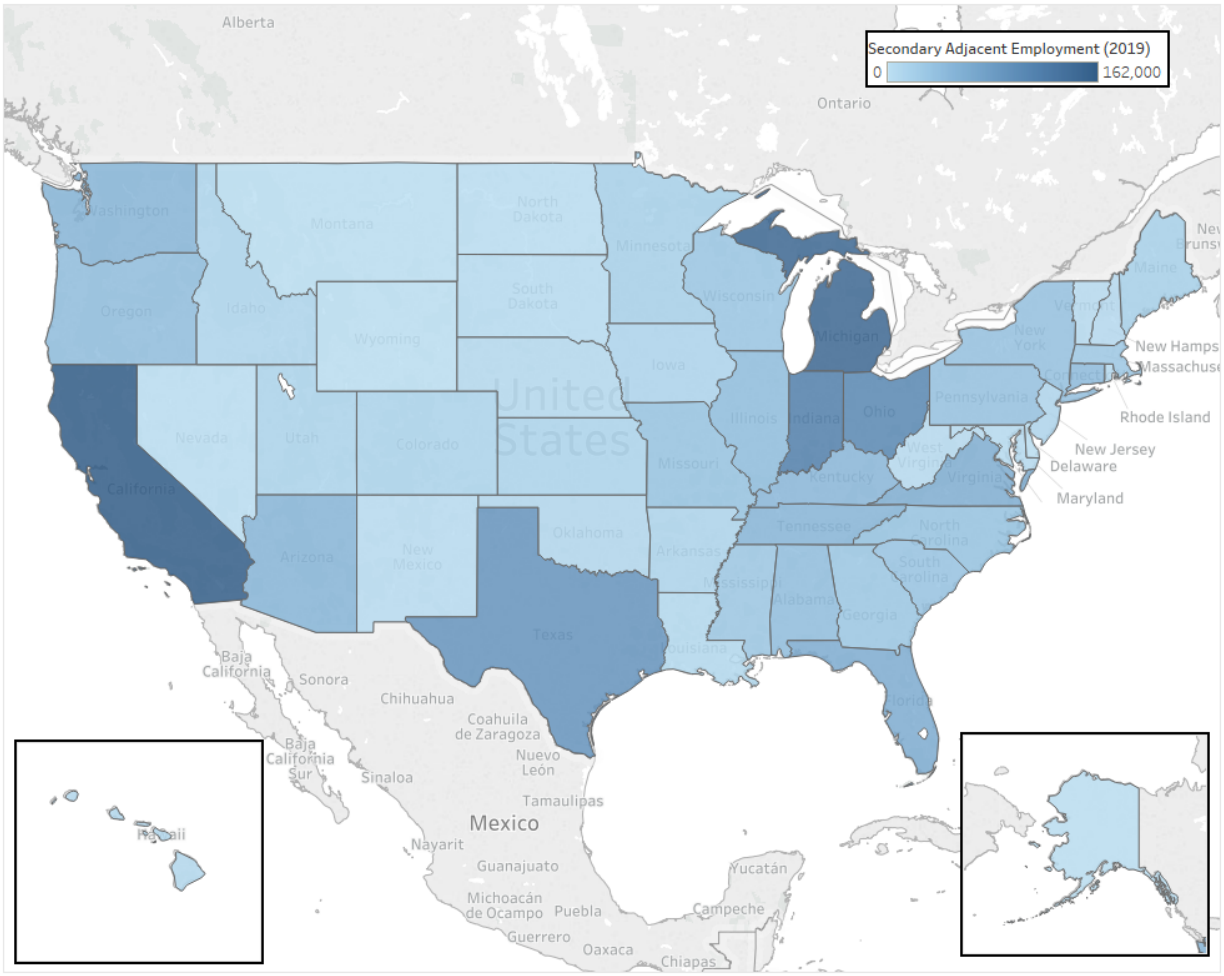
Except Coil Winders, Tapers, and Finishers					
Industrial Engineers	231,313	281,971	291,726	Bachelor's degree	$92,700
Assemblers and Fabricators, All Other	272,409	261,069	223,594	High school diploma or equivalent	$34,800
Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	107,427	142,853	139,209	High school diploma or equivalent	$38,400

Secondary Adjacent Manufacturing Industries

Industry Analysis

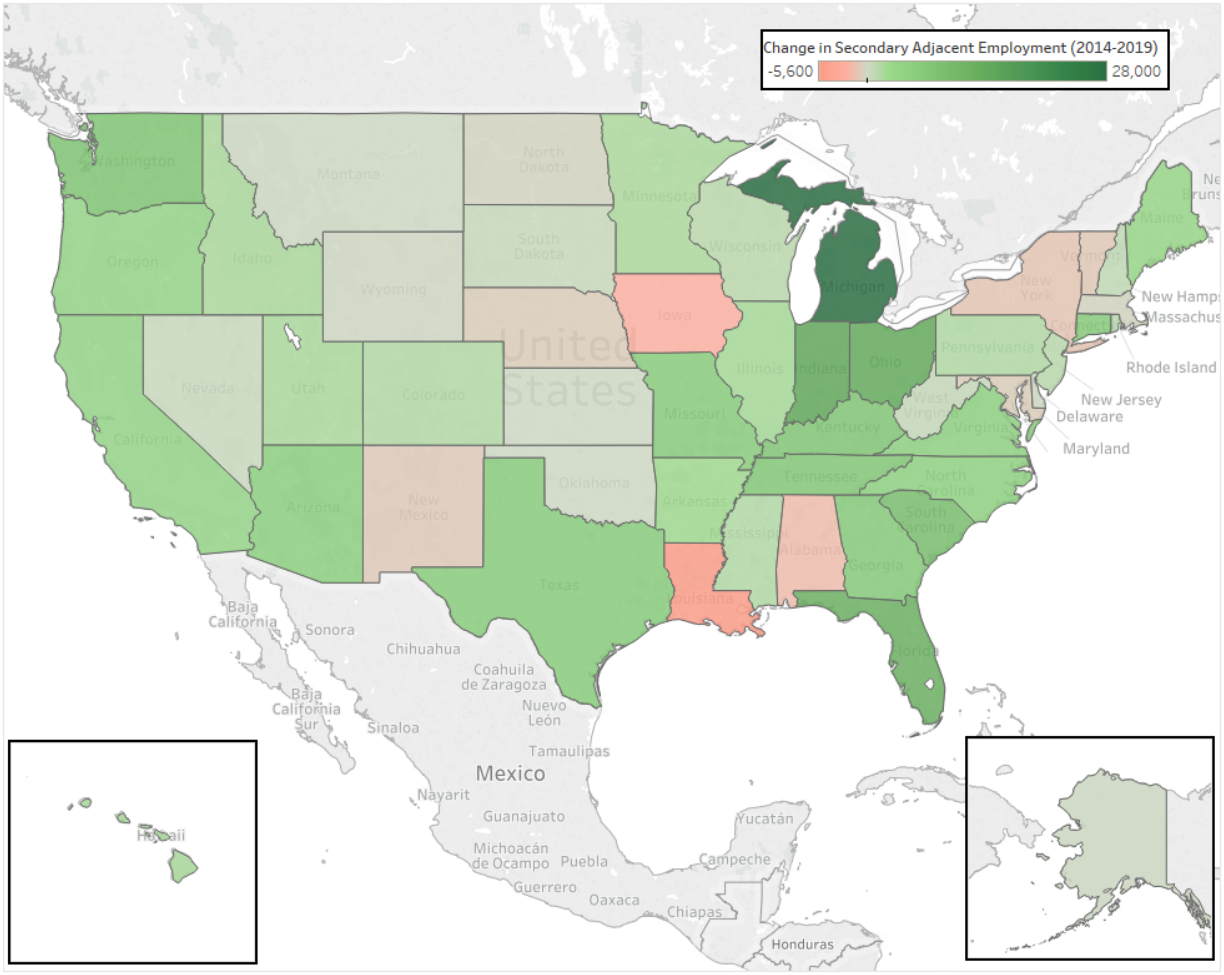
More than 1.6 million people work in Secondary Adjacent Manufacturing Industries (SAMI) across the U.S. California (162,400 workers), Michigan (149,000), and Indiana (117,900) have the greatest number of SAMI workers (Figure 11).

Figure 11: Secondary Adjacent Manufacturing Industry Employment, 2019



SAMIs added more than 157,00 jobs between 2014 and 2019. Michigan (+28,400 jobs), Indiana (+14,300), and Ohio (+13,900) led the country in SAMI jobs added (Figure 12). Louisiana (-5,600 jobs), Iowa (-2,400), and Alabama (-1,700) experienced the greatest losses in SAMI employment during this time. Growth in ET activity presents an opportunity for displaced SAMI workers to take on jobs that would require some training or upskilling but largely build on the existing skillsets of these workers.

Figure 12: Change in Secondary Adjacent Manufacturing Industry Employment, 2014-2019



Occupational Analysis – A Workforce Perspective

There are nearly 8.4 million people who hold jobs that are among the ten-most common Secondary Adjacent Occupations. Seven of the ten occupations listed have median annual wages that exceed the national rate across all occupations (Table 4).[42]

Table 4: Key Secondary Adjacent Occupations

Key Occupations	2014 Jobs	2019 Jobs	Projected 2024 Jobs[43]	Typical Entry-Level Education	Median Annual Wages[44]
Laborers and Freight, Stock, and Material Movers, Hand	2,409,613	2,909,656	2,968,796	None	$32,100
Software Developers and Software Quality Assurance Analysts and Testers	1,091,682	1,399,672	1,582,545	Bachelor's degree	$111,600
Team Assemblers	1,054,840	1,144,259	1,001,760	High school diploma or equivalent	$34,800
First-Line Supervisors of Production and Operating Workers	621,694	646,883	608,271	High school diploma or equivalent	$65,200
Inspectors, Testers, Sorters, Samplers, and Weighers	488,862	573,214	516,629	High school diploma or equivalent	$43,000
Welders, Cutters, Solderers, and Brazers	395,393	432,206	414,541	High school diploma or equivalent	$45,200
Machinists	395,715	392,559	364,630	High school diploma or equivalent	$46,100
Mechanical Engineers	258,441	304,400	306,285	Bachelor's degree	$93,500
Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	255,726	283,861	277,019	High school diploma or equivalent	$36,900
Industrial Engineers	231,313	281,971	291,726	Bachelor's degree	$92,700

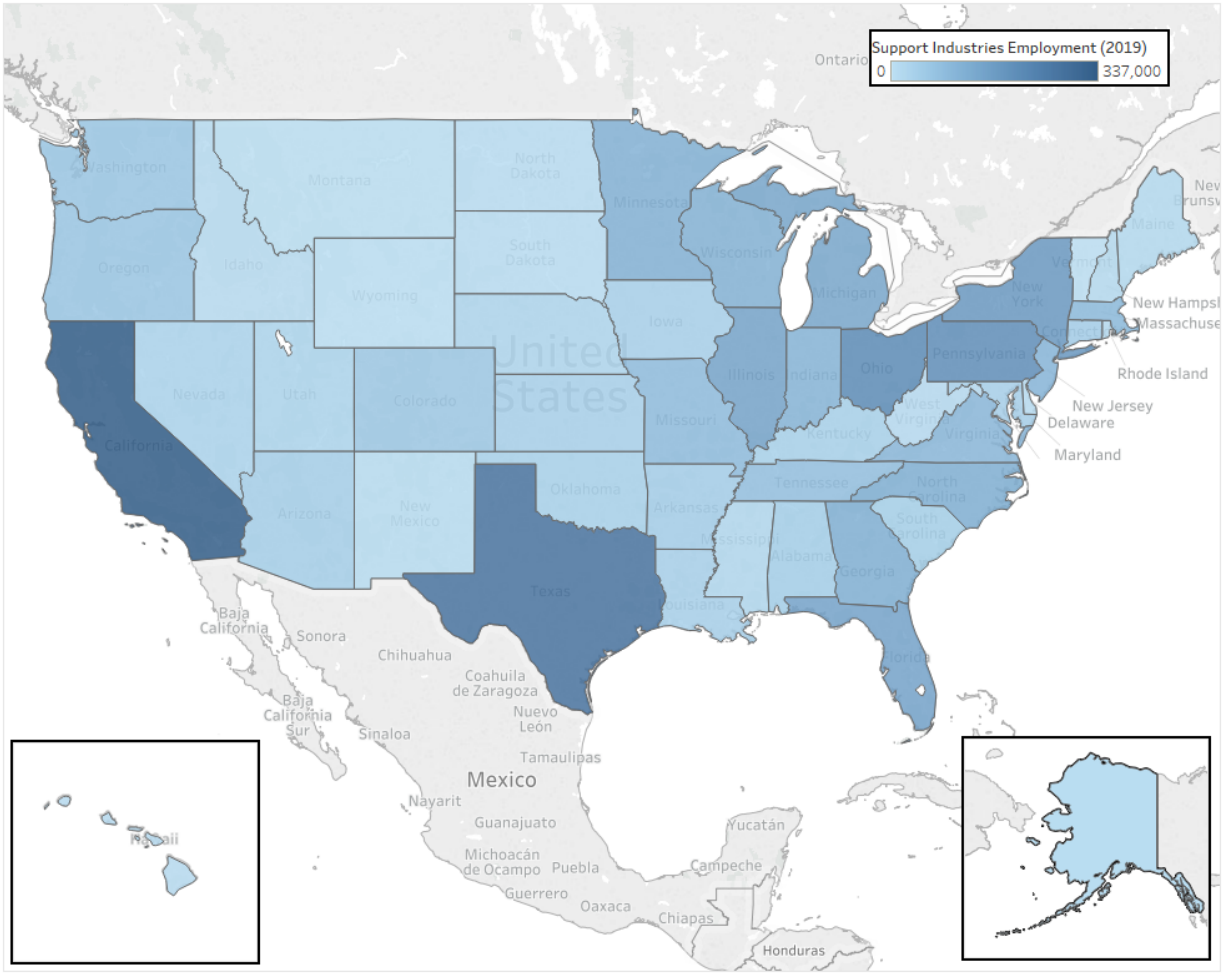
[42] Occupational Employment Statistics. U.S. Bureau of Labor Statistics. May 2019 Occupational Employment and Wage Estimates. National median hourly rate for all occupations is $20.17. Median annual wages are $41,954 based on a full-time worker working 40 hours a week.
[43] These projections are from JobsEQ and based on occupation-specific growth across the state. They are not based on ET growth estimates.
[44] Wages do not include benefits, such as healthcare or dental insurance.

Support Industries

Industry Analysis

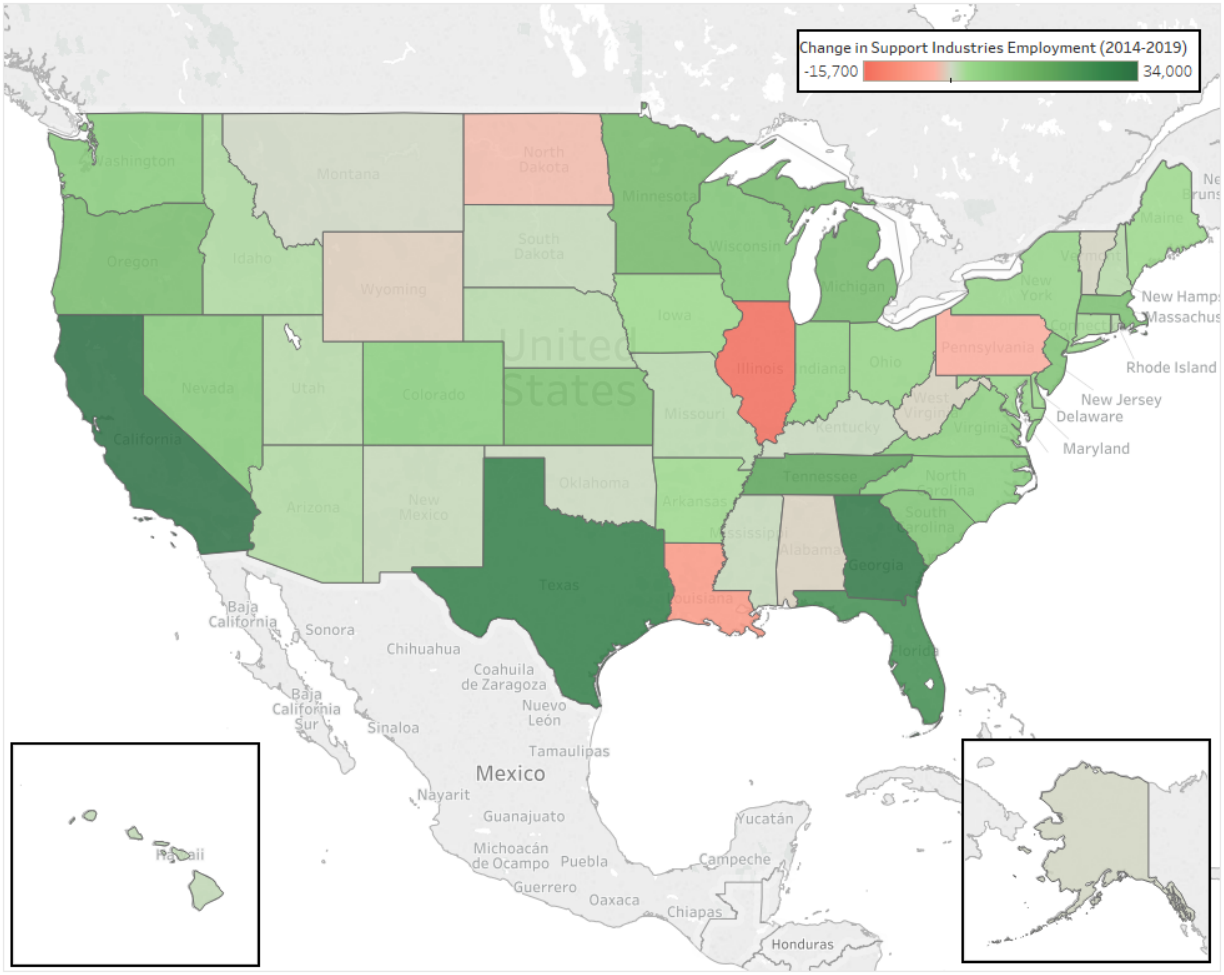
More than 3.6 million people worked in Support Industries (SI) in 2019 (Figure 14). Corporate, Subsidiary, and Regional Managing Offices comprised 2.3 million of these jobs, and Industrial Machinery and Equipment Merchant Wholesalers accounted for another 334,700 jobs.

Figure 13. Support Industry Employment, 2019



Support Industry jobs increased by 278,800 between 2014 and 2019. California (+33,900 jobs), Georgia (+32,100), and Texas (+30,100) saw the greatest increase in jobs. Ten states saw SI employment decline duirng this time, including Illinois (-15,700 jobs), Louisiana (-7,500), and Pennsylvania (-3,500) (Figure 14). Growth in ET could spur additional demand for the goods and services provided by SI, increasing the industries' demand for workers to meet these new production demands.

Figure 14: Change in Support Industries Employment, 2014-2019



Occupational Analysis

The ten-most common occupations found within Support Industries account for 16.5 million jobs across the U.S. Though half of these occupations typically require a Bachelor's degree for entry-level positions, four require only a high school diploma or equivalent (Table 5). This highlights that SI occupations are available for a range of workers with different backgrounds.

Table 5: Key Support Industry Occupations

Key Occupation	2014 Jobs	2019 Jobs	Projected 2024 Jobs[45]	Typical Entry-Level Education	Median Annual Wages[46]
Accountants and Auditors	1,267,984	1,390,773	1,391,169	Bachelor's degree	$79,500
Bookkeeping, Accounting, and Auditing Clerks	1,758,610	1,699,935	1,540,873	Some college, no degree	$43,000
Customer Service Representatives	2,442,375	2,871,378	2,833,853	High school diploma or equivalent	$37,300
Financial Managers	573,117	664,937	706,704	Bachelor's degree	$147,500
General and Operations Managers	1,946,326	2,370,848	2,374,388	Bachelor's degree	$123,000
Machinists	395,715	392,559	364,630	High school diploma or equivalent	$46,100
Office Clerks, General	2,868,740	3,057,889	2,853,723	High school diploma or equivalent	$36,400
Project Management Specialists and Business Operations Specialists, All Other	1,081,821	1,262,282	1,307,141	Bachelor's degree	$80,200
Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	1,441,716	1,405,261	1,336,438	High school diploma or equivalent	$71,100
Software Developers and Software Quality Assurance Analysts and Testers	1,091,682	1,399,672	1,582,545	Bachelor's degree	$111,600

[45] These projections are from JobsEQ and based on occupation-specific growth across the state. They are not based on ET growth estimates.
[46] Wages do not include benefits, such as healthcare or dental insurance.

Company Snapshot

Hickok Waekon

Ohio and Mississippi

Hickok Waekon is a manufacturer of component-specific diagnostic scan tools. Established in 1910, the company currently has 14 employees at its headquarters in Cleveland, Ohio, and another 36 manufacturing employees in Greenwood, Mississippi. The diagnostic scan tool landscape has changed considerably in recent years, as Internal Combustion Engine (ICE) vehicles have developed increasingly sophisticated onboard computer systems and componentry. The rise of electric vehicles presents another transformation that is disrupting the diagnostic tool industry. On one hand, electric powertrains have more modules than even modern ICE vehicles. This means that there are more electric components to test and subsequent tools to develop. On the other hand, the absence of combustion components removes the need for certain combustion-specific scan tools.

Ultimately, the transition to EVs will likely neither substantially increase nor decrease the demand for diagnostic scan tools. The landscape has simply changed. As CEO Patrick Bauman noted, "there's a need to understand things differently, and everything has become more precise." One illuminating example Mr. Bauman provided was that diagnosing and finding a hair-sized leak in a battery presents a new challenge for the engineering team compared to monitoring pressure differences in exhaust coming out of a tailpipe. The changes at Hickok Waekon offer a glimpse of some of the changes other non-manufacturing supply chain industries are facing, as ET changes the type of work rather than the quantity.

WORKFORCE DEMOGRAPHICS

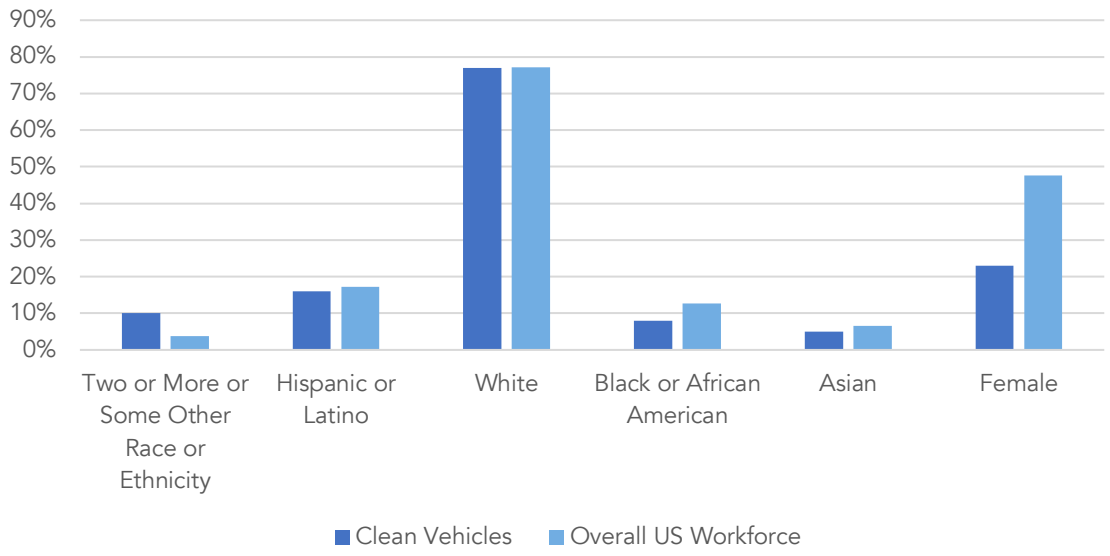
The workers in clean vehicle[47] and Adjacent and Support industries are similar in their demographics to the overall workforce, though women are substantially underrepresented, accounting for about half the share of jobs they do within the broader economy (Figure 15). Black or African-American worker representation among the clean vehicle workforce is slightly below national workforce averages, and slightly higher among Primary Adjacent Industries. This strong representation is likely reflective of the broader U.S. automotive manufacturing industry, which has historically employed a high rate of Black or African-American workers. In 2020, 18.2% of automotive manufacturing workers were Black or African American, a rate 50% greater than the share of working age Black or African Americans.[48]

Tracking the demographics of workers is one important way to ensure that the significant economic benefits from the growth of the ET sector are accessible and distributed equitably. Lessons learned from the traditional automobile sector, as well as expanding outreach, awareness, and education and training opportunities to underrepresented communities can ensure that meaningful career opportunities are accessible to all.

[47] Clean vehicle workforce includes workers involved with hybrid electric vehicles, plug-in hybrid vehicles, electric vehicles, natural gas vehicles, hydrogen vehicles, and fuel cell vehicles.

[48] 2020 Employed persons by detailed industry, sex, race, and Hispanic or Latino ethnicity. Labor Force Statistics from the Current Population Survey. U.S. Bureau of Labor Statistics.

Figure 15. Clean Vehicle Workforce Demographics



Immediate Adjacent Industry Workforce Demographics

The Immediate Adjacent workforce is generally aligned with the demographics of the overall workforce in the U.S., though women are substantially underrepresented. While women make up roughly half of the overall workforce (48%), they make up only 24% of IAMI workers (Figure 16). IAMI workers are generally similar to the age demographics of the overall workforce, though there is a slightly higher proportion of workers between the ages of 19 and 34 (Figure 17).

Figure 16. Immediate Adjacent Workforce Demographics

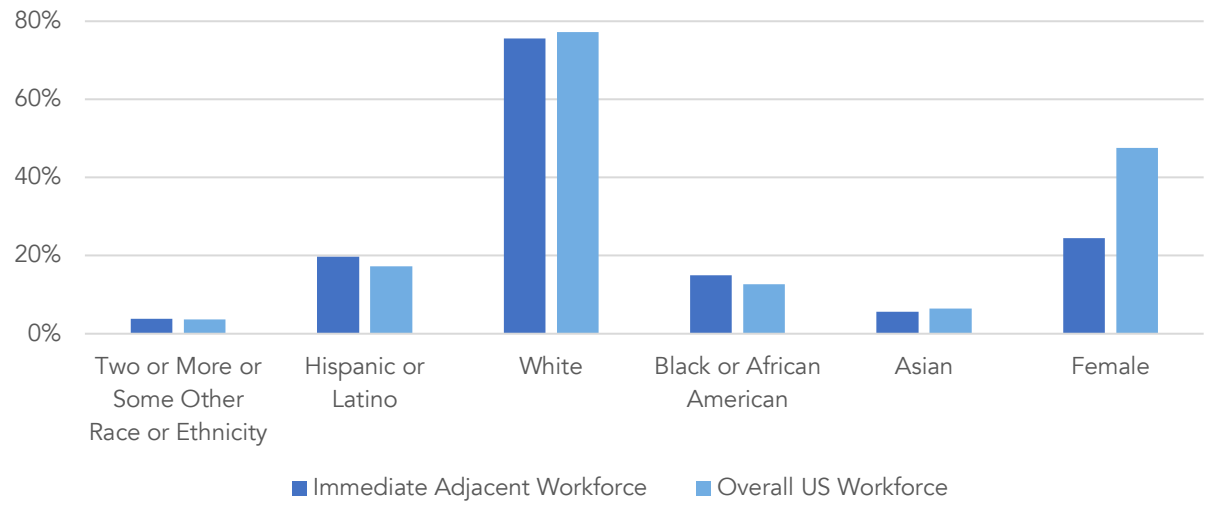
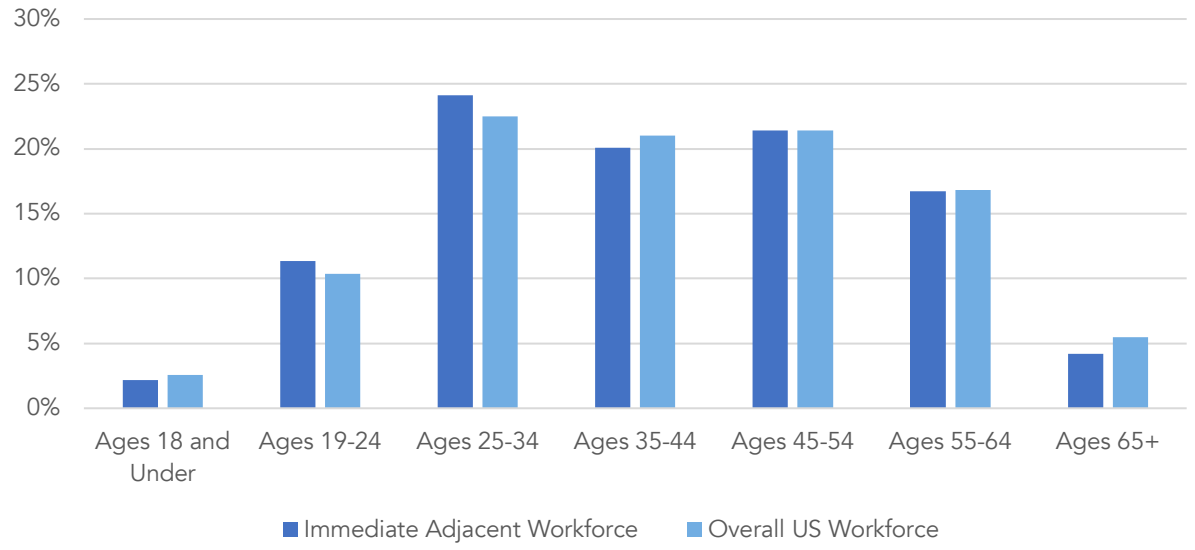


Figure 17. Age Distribution of Immediate Adjacent Workforce



Secondary Adjacent Workforce Demographics

The Secondary Adjacent Industry workforce is demographically similar to the Primary Adjacent Industry workforce. While the SAMI workforce is generally representative by race, and ethnicity, women make up a small share of SAMI workers (22%) (Figure 18). The SAMI workforce is also slightly younger than the overall workforce, with a greater share of workers between the ages of 25 and 34 (Figure 19).

Figure 18. Secondary Adjacent Workforce Demographics

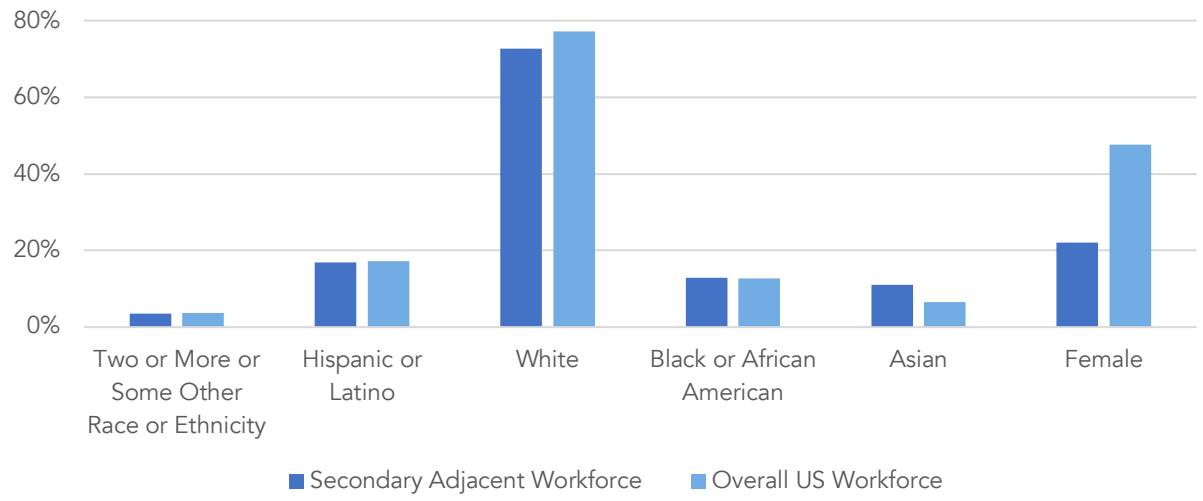
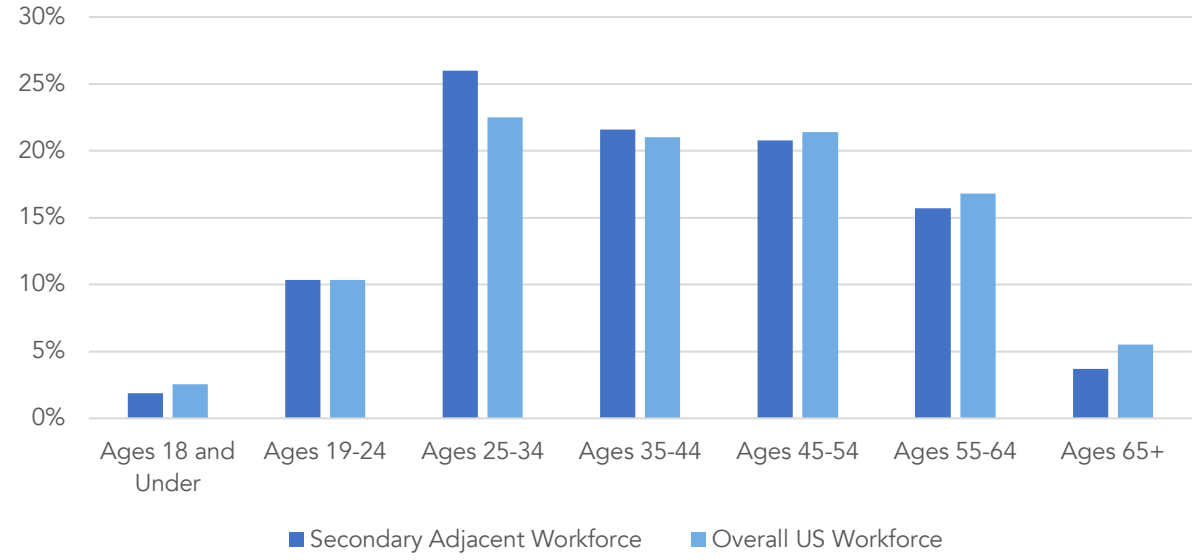


Figure 19. Age Distribution of Secondary Adjacent Workforce



Support Industry Workforce Demographics

The Support Industry workforce has a slightly lower share of Black and Hispanic or Latino workers than the overall workforce (Figure 20). The SI workforce is also most heavily represented among prime-age workers (those between the ages of 25 and 64) (Figure 21).

Figure 20. Support Industry Workforce Demographics

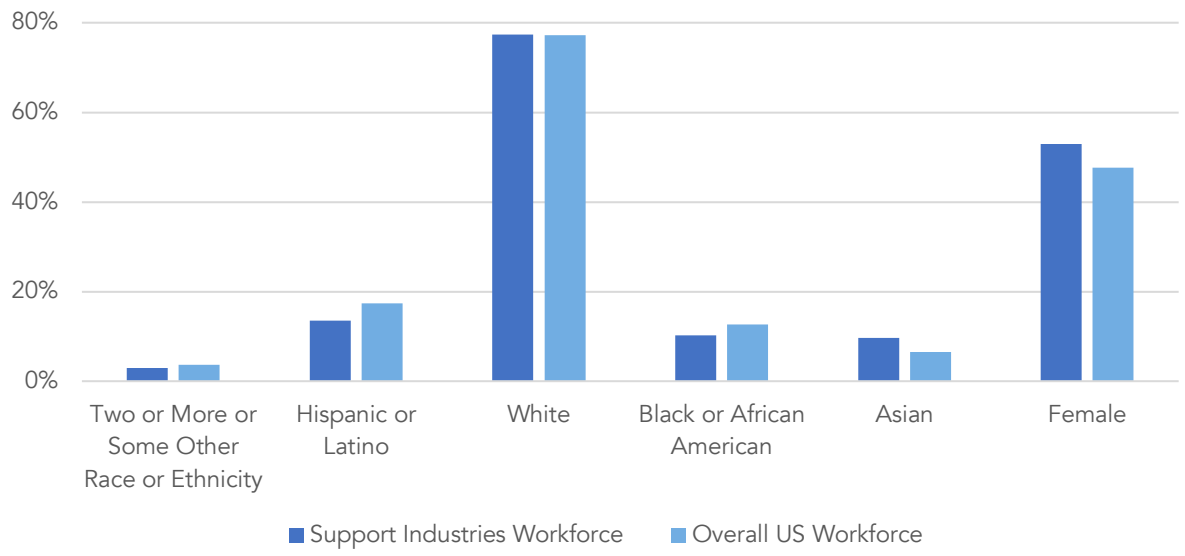
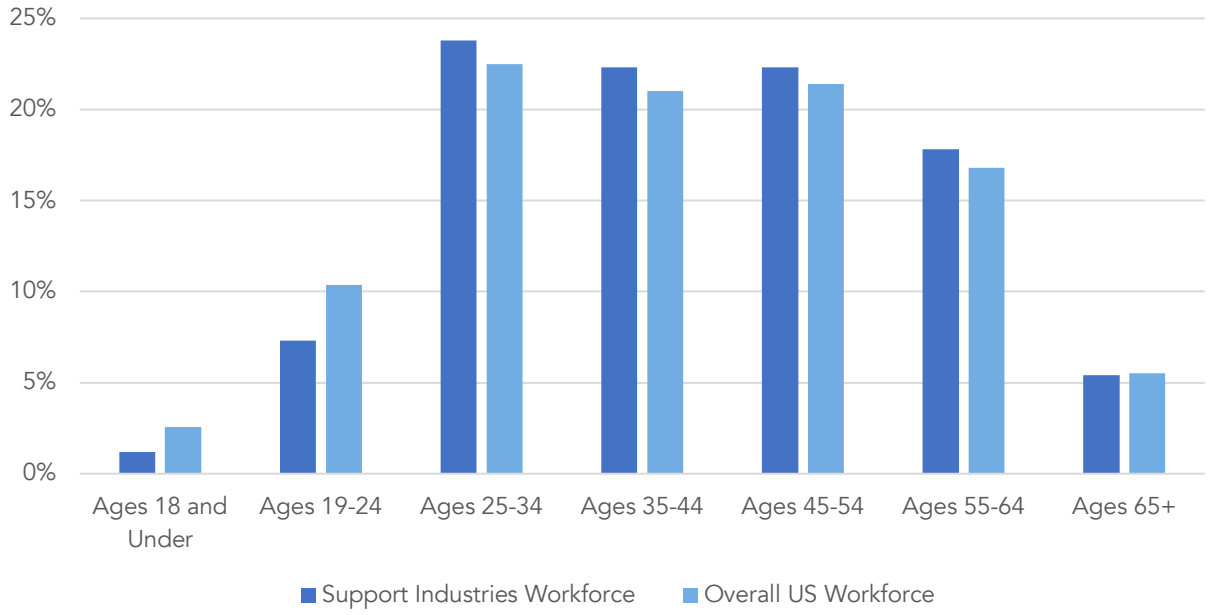


Figure 21. Age Distribution of Support Industry Workforce



Company Snapshot

Highland Electric Transportation

Numerous States

Highland Electric Fleets (Highland) is a turnkey electrification solutions provider headquartered in Beverly, Massachusetts, that enables municipal fleet electrification at scale. Today, the company specializes in helping school districts and third-party school bus fleet providers to operate electric school bus fleets without the traditional challenges associated with acquiring, integrating, and managing a large electric fleet. Before Highland, school districts often balked at the need to take on the additional up-front capital costs, develop additional electrical infrastructure, and efforts to upskill existing drivers and fleet maintenance staff that are required to transition to an all-electric fleet. Highland's turnkey solutions have removed these barriers for school districts by managing the financing, infrastructure additions and management, vehicle deployment, and training associated with integrating a new electric fleet.

Since its founding in 2018, Highland has hit the ground running. In February 2021, Maryland's Montgomery County Board of Education announced the approval of a 16-year, $169 million contract with Highland for 326 electric buses that has the potential to expand to replace all 1,422 busses in the county's fleet. This deal represents the largest school bus fleet electrification project in the United States. Highland currently has projects in four different states around the U.S., and a growing pipeline of active discussions spread across 17 states. As America's ground transportation continues to electrify, Highland will be there to ensure a smooth transition for municipalities looking to make their fleets cleaner and more efficient.

CONCLUSION

With more than 155,000 workers and 15,200 businesses generating $29 billion in GDP, it is clear that ET is already a substantial component of the U.S. automotive sector. Yet, the ET sector is still in its early days, each year becoming a larger portion of the U.S. economy. It is projected that by 2024 there will be 296,000 workers involved in ET, nearly twice the number as five years prior. Given this high growth rate, it is imperative to understand the existing industries and workforce that support them, examine the strengths, as well as the challenges, of the ET sector, and develop policies accordingly.

The strengths of the ET sector are numerous. In addition to its current size, Adjacent Industries—industries that are closest to ET-activity but not currently involved—contain a sizable workforce that could transition to ET work with minimal upskilling and training. Additionally, Adjacent Industry employment declined in several states and new growth in ET-related activity could serve as a lifeline to these displaced workers. Adjacent Industry workers are also generally representative of the broader U.S. workforce by race and ethnicity, though women continue to make up a disproportionately low percentage of this workforce.

The ET supply chain also has several problematic bottlenecks that could frustrate growth. Crucial components, including batteries and semiconductors, are in short supply and require immense specialization. Policies that incentivize research and development and alleviate barriers that prevent manufacturers from retooling will be important in removing ET supply chain bottlenecks.

Consumer trends suggest that the demand for ET will continue to accelerate. This presents the U.S. with an opportunity to support the growth and acceleration of the domestic ET supply chain and create new jobs across a range of occupations, including factory and assembly roles, software development, and operations and administration. The growth of the ET economy will provide new job opportunities to workers across the U.S. with a variety of backgrounds and education levels while also fostering an economy that is less dependent on gasoline and is more technologically advanced.

APPENDIX A: METHODOLOGY

Employment and GSP

Employment and GSP extrapolations were performed using data collected for this report, as well as data from the 2019 United States Energy Employment Report (USEER) and JobsEQ. The methodology used for the 2019 USEER meets the highest statistical and methodological standards and has been reviewed by the Bureau of Labor Statistics (BLS) and the Department of Energy (DOE). More details about the methodology can be found here: usenergyjobs.org.

Data Collection

The research team utilized desktop research, phone calls, email, and other forms of outreach to generate a database of companies known to be active in ET. Firms from the potential database (this database was comprised of companies from industries which were believed to be involved in ET) were first examined through desktop research to determine if they were related to ET activity. Any firms that were confirmed or identified as potentially involved in ET were called via telephone up to two times. Once phone contact was established, BW staff would confirm involvement in ET, and ask supplementary questions confirming employment counts and asking about in-state suppliers and customers. If phone contact could not be established, voicemails were left and, when possible, emails sent.

BW Research employed a number of strategies to maximize the data collection effort given the considerable size of the potential database. These approaches are outlined below:

- Prioritization of manufacturing NAICS codes. Manufacturing roles present the greatest opportunity for job creation, as manufacturing is generally more labor intensive and has substantial downstream supply chains and workforces that support them.

- "Snowball" methodology. Once a firm confirmed that they were involved in ET in some capacity, researchers followed up by asking about any relevant in-state

suppliers and customers. This allowed the research team to develop a more complete picture of the supply chain.

- Among industries which the research team did not exhaust via phone interviews, staff conducted desktop research to identify relevant firms that advertised ET-related products or services.

Of the 200,800 firms in the assembled potential database, 32,800 firms were examined closely by the research team. All manufacturing businesses in the database were examined.

Some of the industry definitions of electric transportation used in this report are not included and reported in the USEER motor vehicles section. These industries include:

- Automobile Retail (NAICS 4411)
- Rail Transportation (NAICS 4281)
- Farm and Garden Machinery and Equipment Merchant Wholesalers (NAICS 42382)
- Agricultural Implement Manufacturing (NAICS 33311)
- Railroad Rolling Stock Manufacturing (NAICS 33651)
- Industrial Machinery and Equipment Merchant Wholesalers (NAICS 42383)
- Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Merchant Wholesalers (NAICS 42361)
- Engineering Services (NAICS 54133)
- Electrical Contractors and Other Wireless Installation Contractors (NAICS 23821)
- Power and Communication Line and Related Structures (NAICS 33451)
- Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (NAICS 33451)
- Electrical Equipment Manufacturing (NAICS 33531)
- Plate Work and Fabricated Structural Product Manufacturing (NAICS 33231)

Having confidently determined the involvement of 32,800 firms out of the BLS estimated 640,684 firms in industries that were identified as potentially involved in ET, the margin of error is among these industries is approximately 0.56% for incidence.

APPENDIX B: INDUSTRY GROUP DEFINITIONS

Below are the NAICS code definitions for the immediate Adjacent, secondary Adjacent, and Support Industries described in this report.

Table 6: Immediate Adjacent Manufacturing Industries

NAICS Code	Description
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing
334419	Other Electronic Component Manufacturing
335312	Motor and Generator Manufacturing
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing
336111	Automobile Manufacturing
336120	Heavy Duty Truck Manufacturing
336390	Other Motor Vehicle Parts Manufacturing
336510	Railroad Rolling Stock Manufacturing
336991	Motorcycle, Bicycle, and Parts Manufacturing
336999	All Other Transportation Equipment Manufacturing

Table 7: Secondary Adjacent Industries

NAICS Code	Description
333921	Elevator and Moving Stairway Manufacturing
333922	Conveyor and Conveying Equipment Manufacturing
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing
334310	Audio and Video Equipment Manufacturing
334412	Bare Printed Circuit Board Manufacturing
334413	Semiconductor and Related Device Manufacturing
334416	Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing

334417	Electronic Connector Manufacturing
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing
335311	Power, Distribution, and Specialty Transformer Manufacturing
335313	Switchgear and Switchboard Apparatus Manufacturing
335314	Relay and Industrial Control Manufacturing
335991	Carbon and Graphite Product Manufacturing
336112	Light Truck and Utility Vehicle Manufacturing
336212	Truck Trailer Manufacturing
336213	Motor Home Manufacturing
336214	Travel Trailer and Camper Manufacturing
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing
336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing
336340	Motor Vehicle Brake System Manufacturing
336350	Motor Vehicle Transmission and Power Train Parts Manufacturing
336360	Motor Vehicle Seating and Interior Trim Manufacturing
336370	Motor Vehicle Metal Stamping
336412	Aircraft Engine and Engine Parts Manufacturing
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing
336414	Guided Missile and Space Vehicle Manufacturing
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing
336611	Ship Building and Repairing
336612	Boat Building
336992	Military Armored Vehicle, Tank, and Tank Component Manufacturing

Table 8: Support Industries

NAICS Code	Description
331110	Iron and Steel Mills and Ferroalloy Manufacturing
331511	Iron Foundries
332312	Fabricated Structural Metal Manufacturing
332313	Plate Work Manufacturing
332710	Machine Shops
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing
333613	Mechanical Power Transmission Equipment Manufacturing
333618	Other Engine Equipment Manufacturing
423110	Automobile and Other Motor Vehicle Merchant Wholesalers
423120	Motor Vehicle Supplies and New Parts Merchant Wholesalers
423830	Industrial Machinery and Equipment Merchant Wholesalers
551114	Corporate, Subsidiary, and Regional Managing Offices

APPENDIX C: GLOSSARY OF TERMS

Below is a glossary of terms used throughout this report. Additional information on some key occupations can be found in Appendix A.

Aircraft Parts and Auxiliary Equipment Manufacturing: This U.S. industry comprises establishment primarily engaged in (1) manufacturing aircraft parts or auxiliary equipment (except engines and aircraft fluid power subassemblies) and/or (2) developing and making prototypes of aircraft parts and auxiliary equipment. Auxiliary equipment includes such items as crop dusting apparatus, armament racks, inflight refueling equipment, and external fuel tanks.

Assemblers and Fabricators (All Other, Including Team Assemblers): Work as part of a team having responsibility for assembling an entire product or component of a product. Team assemblers can perform all tasks conducted by the team in the assembly process and rotate through all or most of them rather than being assigned to a specific task on a permanent basis. May participate in making management decisions affecting the work. Includes team leaders who work as part of the team.

Automobile Merchant Wholesalers: This industry comprises establishments primarily engaged in the merchant wholesale distribution of new and used passenger automobiles, trucks, trailers, and other motor vehicles, such as motorcycles, motor homes, and snowmobiles.

Automotive Service Technicians and Mechanics: Diagnose, adjust, repair, or overhaul automotive vehicles.

Boat Building Manufacturing: Establishments primarily engaged in building boats. Boats are defined as watercraft not built-in shipyards and typically of the type suitable or intended for personal use. Included in this industry are establishments that manufacture heavy-duty inflatable rubber or inflatable plastic boats (RIBs).

Computer-Controlled Machine Tool Operators, Metal and Plastic: Operate computer-controlled machines or robots to perform one or more machine functions on metal or plastic work pieces.

Cutting, Punching, and Press Machine Setters, Operators, and Tenders: Set up, operate, or tend machines to saw, cut, shear, slit, punch, crimp, notch, bend, or straighten metal or plastic material.

Electrical, Electronic, and Electromechanical Assemblers (Except Coil Winders, Tapers, and Finishers): Assemble or modify electromechanical equipment or devices, such as servomechanisms, gyros, dynamometers, magnetic drums, tape drives, brakes, control linkage, actuators, and appliances.

Electrical and Electronic Goods Merchant Wholesalers: This industry comprises establishments primarily engaged in the merchant wholesale distribution of electrical construction materials; wiring supplies; electric light fixtures; light bulbs; and/or electrical power equipment for the generation, transmission, distribution, or control of electric energy.

Fabricated Structural Metal Manufacturing: This industry comprises establishments primarily engaged in fabricating structural metal products, such as assemblies of concrete reinforcing bars and fabricated bar joists.

First-Line Supervisors of Production and Operating Workers: Directly supervise and coordinate the activities of production and operating workers, such as inspectors, precision workers, machine setters and operators, assemblers, fabricators, and plant and system operators.

Heavy Duty Truck Manufacturing: industry comprises establishments primarily engaged in (1) manufacturing heavy duty truck chassis and assembling complete heavy duty trucks, buses, heavy duty motor homes, and other special purpose heavy duty motor vehicles for highway use or (2) manufacturing heavy duty truck chassis only.

Industrial Machinery and Equipment Merchant Wholesalers: This industry comprises establishments primarily engaged in the merchant wholesale distribution of specialized machinery, equipment, and related parts generally used in manufacturing, oil well, and warehousing activities.

Inspectors, Testers, Sorters, Samplers, and Weighers: Inspect, test, sort, sample, or weigh nonagricultural raw materials or processed, machined, fabricated, or assembled

parts or products for defects, wear, and deviations from specifications. May use precision measuring instruments and complex test equipment.

Iron and Steel Mills and Ferroalloy Manufacturing: This industry comprises establishments primarily engaged in one or more of the following: (1) direct reduction of iron ore; (2) manufacturing pig iron in molten or solid form; (3) converting pig iron into steel; (4) making steel; (5) making steel and manufacturing shapes (e.g., bar, plate, rod, sheet, strip, wire); (6) making steel and forming pipe and tube; and (7) manufacturing electrometallurgical ferroalloys. Ferroalloys add critical elements, such as silicon and manganese for carbon steel and chromium, vanadium, tungsten, titanium, and molybdenum for low- and high-alloy metals. Ferroalloys include iron-rich alloys and more pure forms of elements added during the steel manufacturing process that alter or improve the characteristics of the metal.

Laborers and Freight, Stock, and Material Movers (Hand): Manually move freight, stock, or other materials or perform other general labor. Includes all manual laborers not elsewhere classified.

Machine Shops: Machine shops primarily engaged in machining metal and plastic parts and parts of other composite materials on a job or order basis. Generally machine shop jobs are low volume using machine tools, such as lathes (including computer numerically controlled); automatic screw machines; and machines for boring, grinding, milling, and additive manufacturing.

Machinists: Set up and operate a variety of machine tools to produce precision parts and instruments. Includes precision instrument makers who fabricate, modify, or repair mechanical instruments. May also fabricate and modify parts to make or repair machine tools or maintain industrial machines, applying knowledge of mechanics, mathematics, metal properties, layout, and machining procedures.

Mechanical Engineers: Perform engineering duties in planning and designing tools, engines, machines, and other mechanically functioning equipment. Oversee installation, operation, maintenance, and repair of equipment such as centralized heat, gas, water, and steam systems.

Motor and Generator Manufacturing: This U.S. industry comprises establishments primarily engaged in manufacturing electric motors (except internal combustion engine starting motors), power generators (except battery charging alternators for internal combustion engines), and motor generator sets (except turbine generator set units).

Motor Home Manufacturing: Type of self-propelled recreational vehicle (RV) which offers living accommodation combined with a vehicle engine.

Motor Vehicle Manufacturing: The motor vehicles manufactured in this industry include automobiles, sport-utility vehicles (SUVs), vans and pickup trucks, heavy duty trucks, buses, truck trailers, and motor homes. It also includes the manufacturing of the parts that go into these vehicles, such as the engine, seats, brakes, and electrical systems.

Multiple Machine Tool Setters, Operators, and Tenders (Metal and Plastic): Set up, operate, or tend more than one type of cutting or forming machine tool or robot.

Non-Ferrous Metal Foundries: Establishments primarily engaged in manufacturing nonferrous metal castings (including alloys), except all die-castings and other castings of aluminum or copper.

Other Electronic Component Manufacturing: Manufacturing electronic components (except bare printed circuit boards; semiconductors and related devices; electronic capacitors; electronic resistors; coils, transformers and other inductors; connectors; and loaded printed circuit boards).

Other Motor Vehicle Parts Manufacturing: Primarily engaged in manufacturing and/or rebuilding motor vehicle parts and accessories (except motor vehicle gasoline engines and engine parts, motor vehicle electrical and electronic equipment, motor vehicle steering and suspension components, motor vehicle brake systems, motor vehicle transmissions and power train parts, motor vehicle seating and interior trim, and motor vehicle stampings).

Plate Work Manufacturing: Industry comprises establishments primarily engaged in manufacturing fabricated metal plate work by cutting, punching, bending, shaping, and welding purchased metal plate.

Power, Distribution, and Specialty Transformer Manufacturing: Engaged in manufacturing power, distribution, and specialty transformers (except electronic components). Industrial-type and consumer-type transformers in this industry vary (e.g., step up or step down) voltage but do not convert alternating to direct or direct to alternating current.

Railroad Rolling Stock Manufacturing: This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing and/or rebuilding locomotives, locomotive frames and parts; (2) manufacturing railroad, street, and rapid transit cars and car equipment for operation on rails for freight and passenger service; and (3) manufacturing rail layers, ballast distributors, rail tamping equipment and other railway track maintenance equipment.

Relay and Industrial Control Manufacturing: Establishments primarily engaged in manufacturing relays, motor starters and controllers, and other industrial controls and control accessories.

Sales Representatives, Wholesale and Manufacturing (except Technical and Scientific Products): Inspect, test, sort, sample, or weigh nonagricultural raw materials or processed, machined, fabricated, or assembled parts or products for defects, wear, and deviations from specifications. May use precision measuring instruments and complex test equipment.

Semiconductor Manufacturing: A semiconductor chip is an electric circuit with many components such as transistors and wiring formed on a semiconductor wafer. An electronic device comprising numerous these components is called "integrated circuit (IC)". The layout of the components is patterned on a photomask (reticle) by computer and projected onto a semiconductor wafer in the manufacturing processes

Switchgear and Switch Board Apparatus Manufacturing: The switchgear and switchboard apparatus manufacturing industry comprise establishments manufacturing switchgear and switchboard apparatus. Switchgear is the combination of electrical disconnect switches and circuit breakers used in electricity transmission to interrupt or reestablish the flow of electricity.

Truck Trailer Manufacturing: This U.S. industry comprises establishments primarily engaged in manufacturing truck trailers, truck trailer chassis, cargo container chassis, detachable trailer bodies, and detachable trailer chassis for sale separately.

Welders, Cutters, Solderers, and Brazers: Use hand-welding, flame-cutting, hand soldering, or brazing equipment to weld or join metal components or to fill holes, indentations, or seams of fabricated metal products.

Wholesale and Manufacturing Sales Representatives: Sell goods for wholesalers or manufacturers to businesses or groups of individuals. Work requires substantial knowledge of items sold.